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Miyano

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[54] **AUTOMATIC TOOL CHANGING MECHANISM FOR A MACHINE TOOL**

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[73] Assignee: **Miyano Machinery USA Inc.,** Wood Dale, Ill.

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[51] **Int. Cl.**^{4} **B23Q 3/157**

[52] **U.S. Cl.** .... **29/568;** 29/26 A; 408/35

[58] **Field of Search** .... 29/568, 26 A, 35.5, 29/40, 48.5 R; 408/35; 211/1.5

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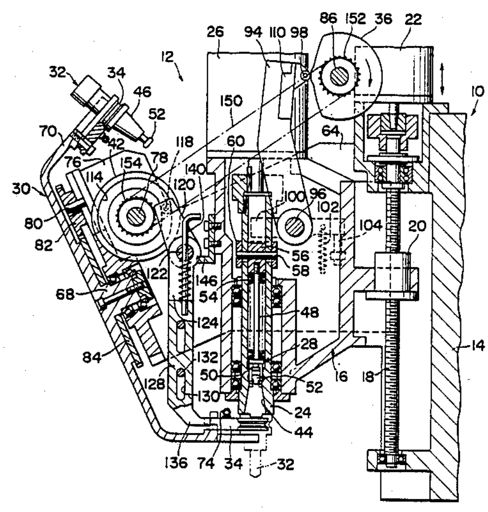
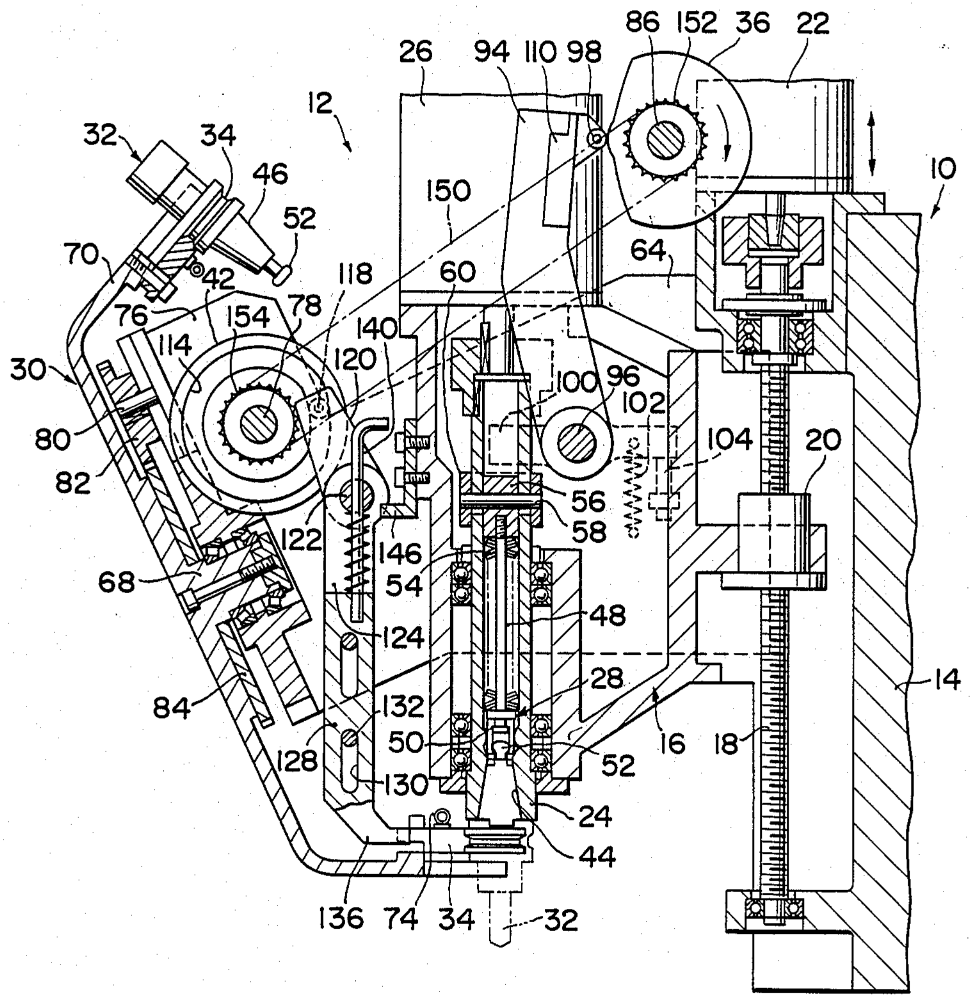
Primary Examiner—William Briggs
Attorney, Agent, or Firm—Ladas & Parry

[57] **ABSTRACT**

An automatic tool changer for a machine tool of the type having an upstanding spindle rotatably mounted to a spindlehead for joint vertical displacement therewith between a lower machining position and an upper retracted position via a tool change position therebetween. The tool changer includes an indexing tool magazine rotatable about a fixed slanting axis and carrying a set of cutting tools at prescribed angular spacings for successively bringing them to a position of axial alignment with the spindle. Also included are a chuck control cam for controlling the chucking and unchucking of the successive cutting tools to and from the spindle, and a gripper control cam for actuating a pair of gripper jaws releasably holding each cutting tool on the tool magazine. The tool magazine, chuck control cam and gripper control cam are all driven mechanically from a common drive motor for quick, reliable tool changing operation.

9 Claims, 9 Drawing Sheets





86 152 36 22
26 94 110 98
12
32 34
46
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70
42
64
118
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76
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30
114
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100 96
102
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50
52
16
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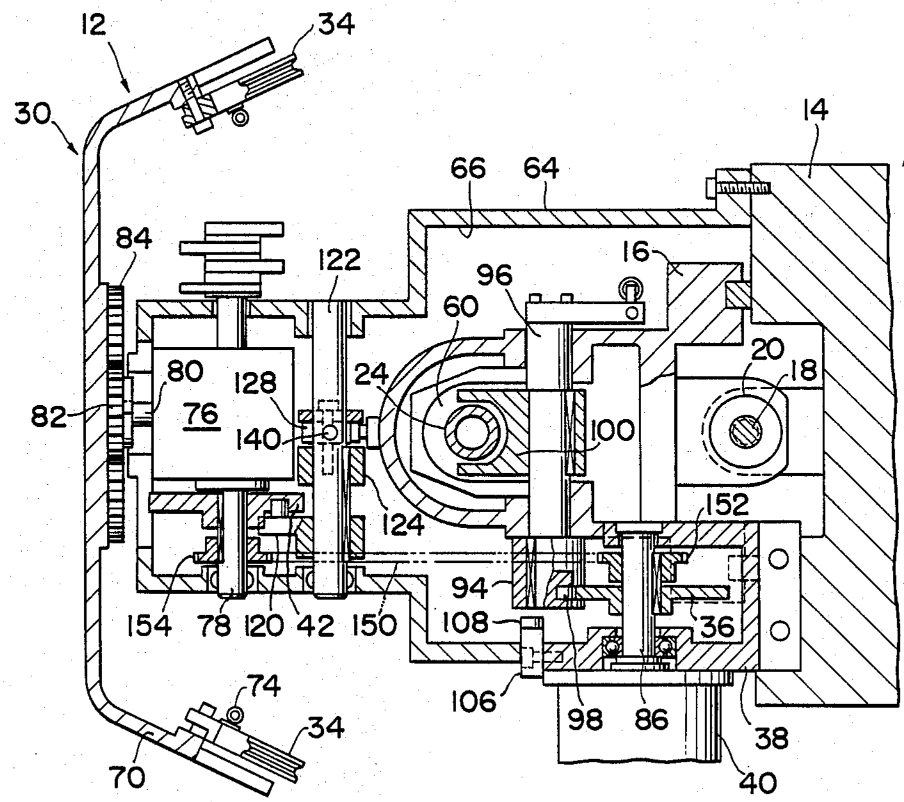
128
130
24
44
136 74 34 32

F I G. 1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34
30
14
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66
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84
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16
96
60
20
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128
24
76
82
140
100
152
124
94
154
78
120
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150
108
36
74
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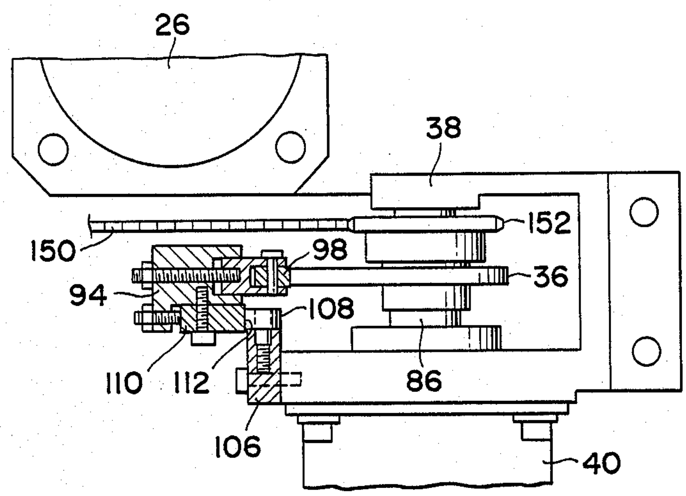
70
40

FIG. 2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86
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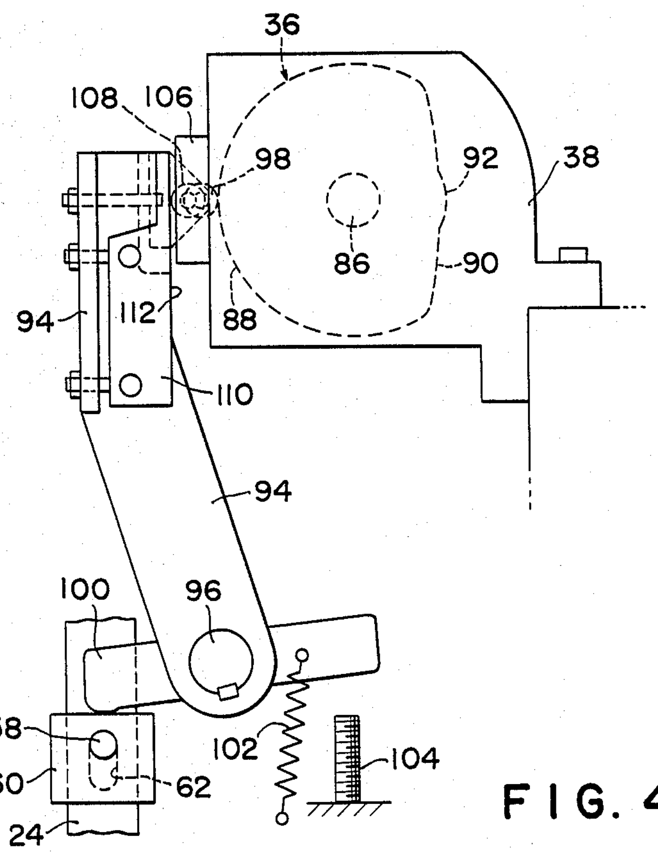
40

FIG. 3


36
108
106
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94
112
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110
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96
58
102
104
60
62
24

FIG. 4

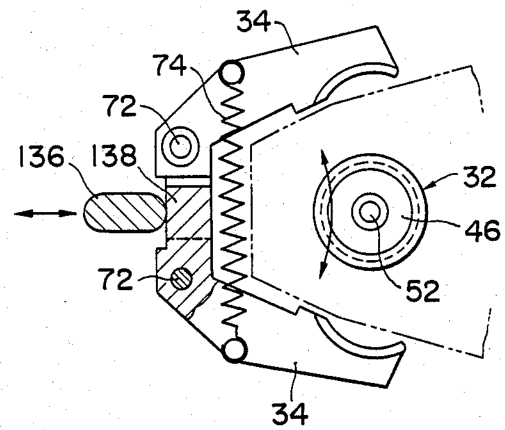
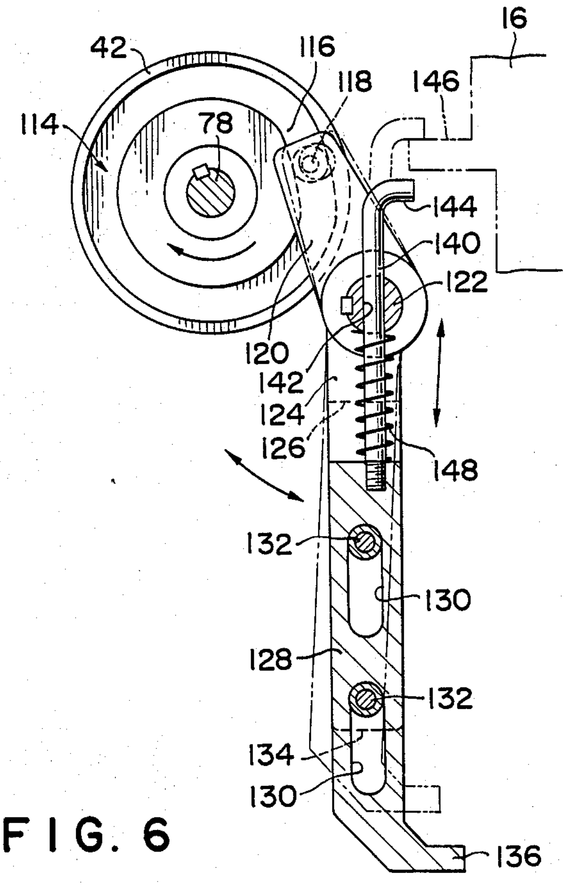

34
74
72
136
138
32
46
72
52
34

FIG. 5


16
42
116
118
146
114
78
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140
122
120
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124
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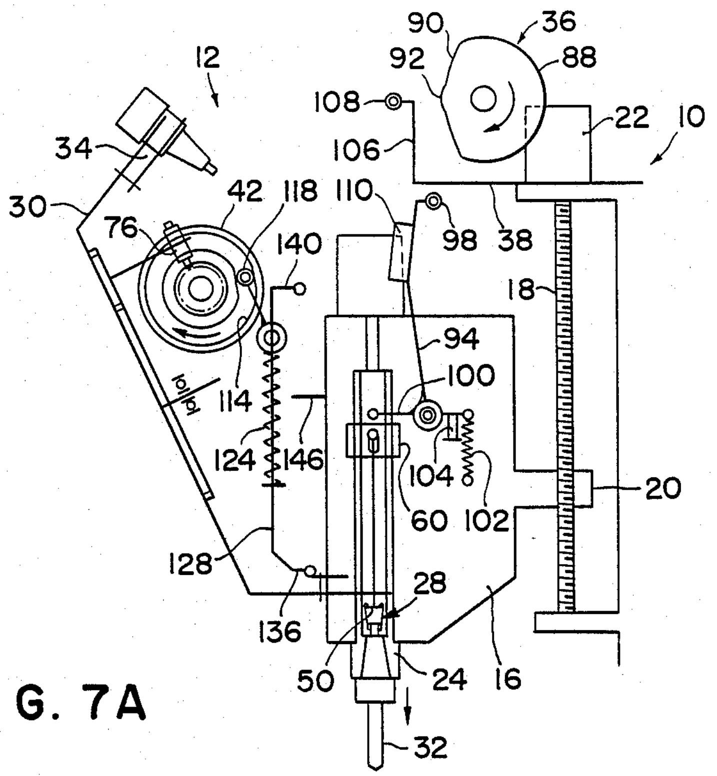
148
132
130
128
132
134
130
136

FIG. 6



90
36
92
88
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108
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10
34
106
30
42
118
110
76
140
98
38
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94
100
114
124
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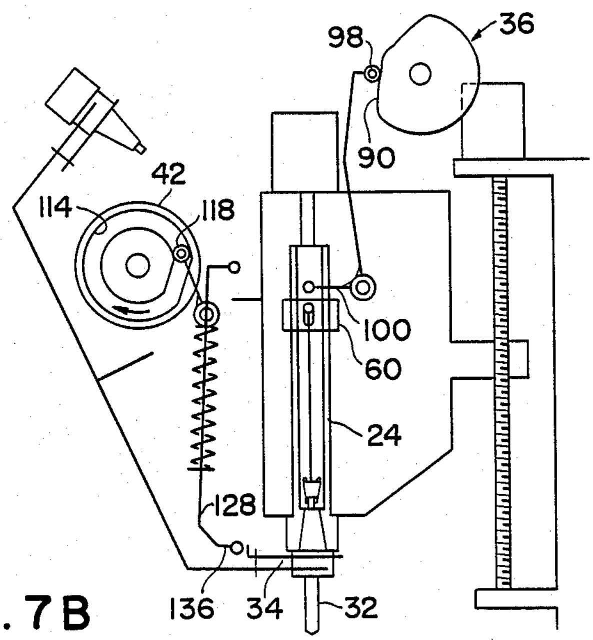
104
20
60
102
128
28
136
50
24
16
32

FIG. 7A



98
36
90
42
114
118
100
60
24
128
136
34
32

FIG. 7B

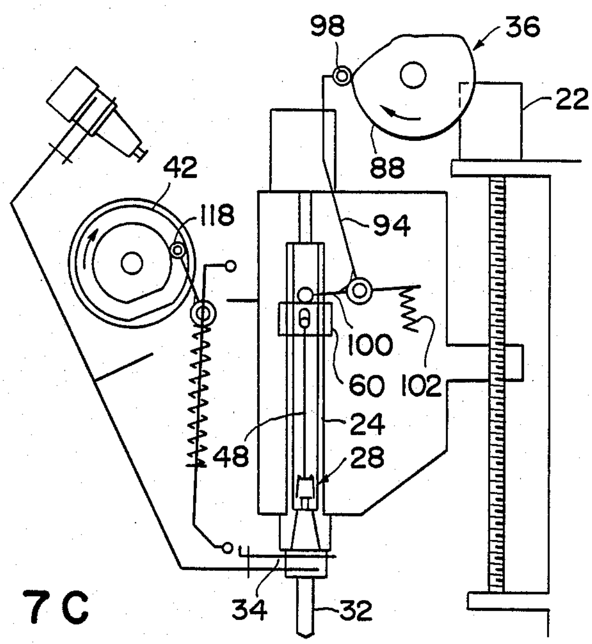


FIG. 7C

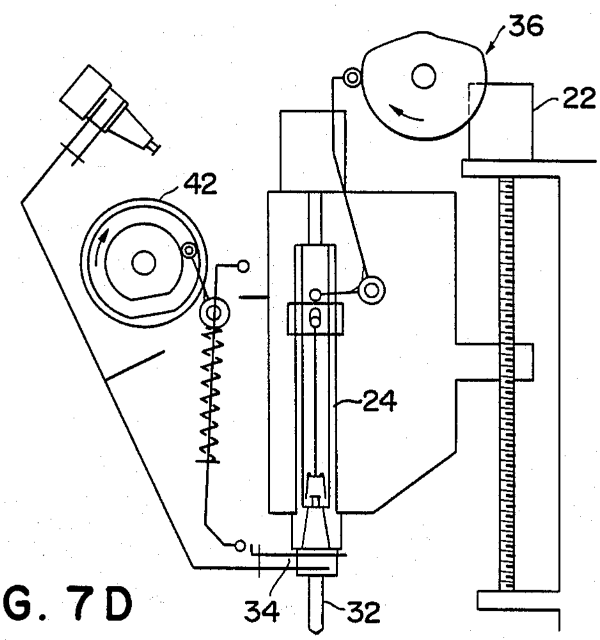
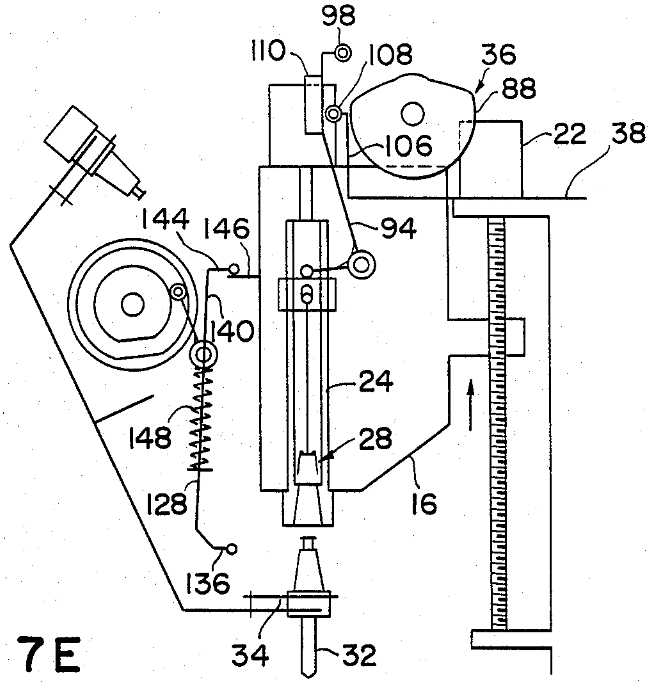


FIG. 7D


98
110
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88
22
38
106
144
146
94
140
24
148
28
128
16
136
34
32

FIG. 7E

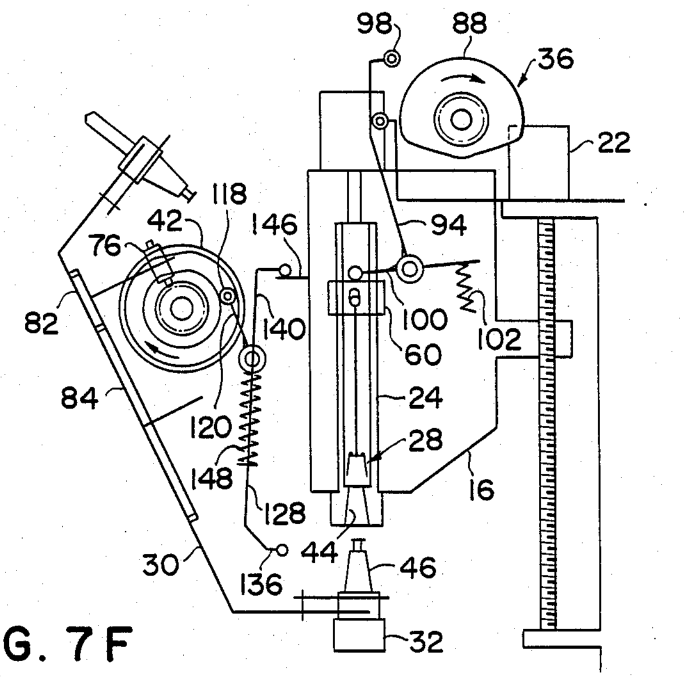
98
88
36
22
118
42
146
94
76
100
82
140
60
102
84
24
120
28
148
16
128
44
46
30
136
32

FIG. 7F

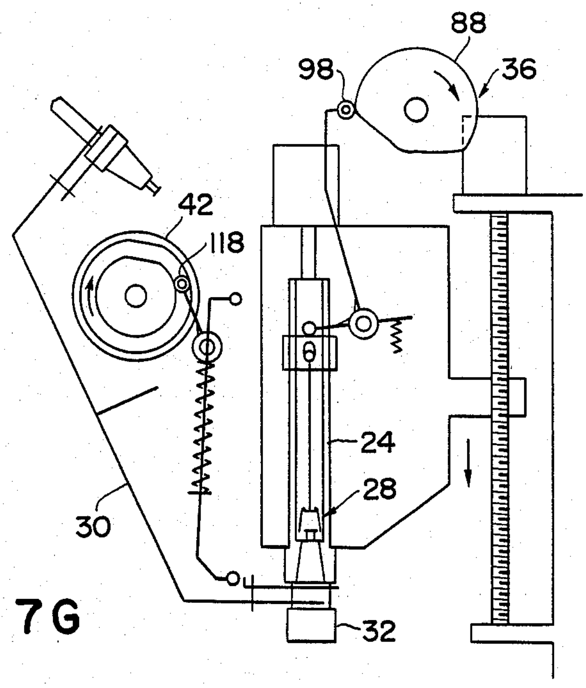

FIG. 7G

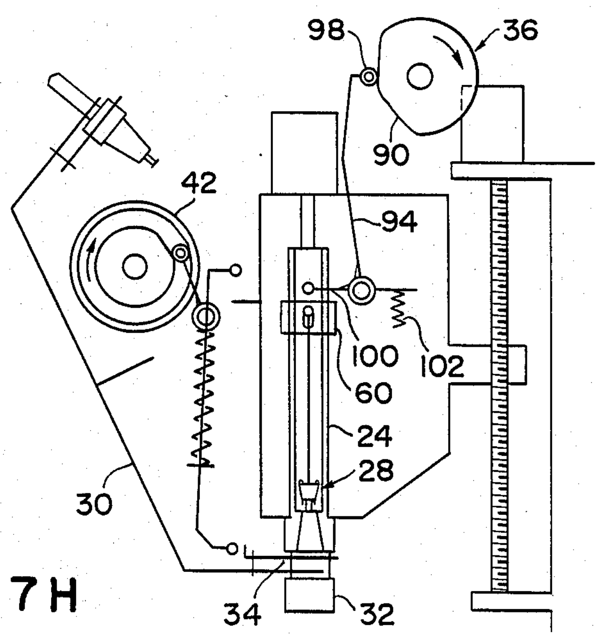

FIG. 7H

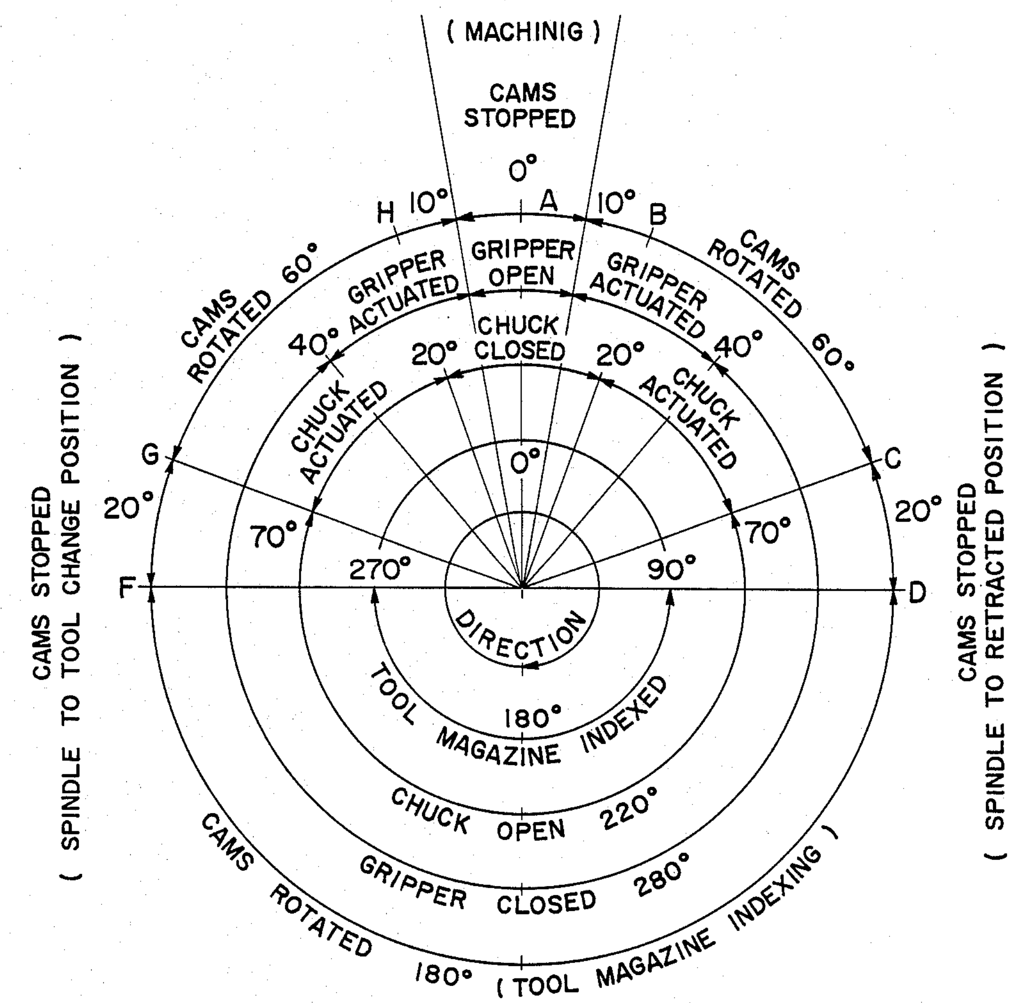
(MACHINIG)
CAMS STOPPED
0°
A
H
B
10°
10°
GRIPPER OPEN
GRIPPER ACTUATED
GRIPPER ACTUATED
CAMS ROTATED 60°
CAMS ROTATED 60°
CHUCK CLOSED
20°
20°
40°
40°
CHUCK ACTUATED
CHUCK ACTUATED
G
C
20°
20°
70°
70°
0°
270°
90°
F
D
DIRECTION
180°
TOOL MAGAZINE INDEXED
CHUCK OPEN 220°
GRIPPER CLOSED 280°
CAMS ROTATED
180° (TOOL MAGAZINE INDEXING)
CAMS STOPPED (SPINDLE TO TOOL CHANGE POSITION)
CAMS STOPPED (SPINDLE TO RETRACTED POSITION)

FIG. 8

AUTOMATIC TOOL CHANGING MECHANISM FOR A MACHINE TOOL

BACKGROUND OF THE INVENTION

This invention relates to machine tools in general and, in particular, to those of the class having a set of different, interchangeable cutting tools mounted at preassigned angular spacings on an indexing tool magazine for selective use. Still more particularly, the invention pertains to an automatic tool changing mechanism in such a class of machines whereby the cutting tools on the tool magazine are successively mounted to, and dismounted from, a spindle moving toward and away from work for performing various operations thereon.

While a variety of automatic tool changers have been suggested and incorporated with machine tools, each such device generally resolves itself into three basic components: (1) an indexing tool magazine holding a set of cutting tools; (2) a tool transfer mechanism for the transfer of each cutting tool between the tool magazine and the spindle; and (3) a chuck for holding each cutting tool on the spindle. These three tool changer components must operate in well timed relation to one another for efficient machining of the work with the successive cutting tools. Heretofore, the components have been fluid actuated and/or cammed, or have been driven by servomechanisms. All such conventional actuating mechanisms are unsatisfactory by reason of complexity in the construction and arrangement of the required parts.

Japanese Patent Laid Open (KOKAI) No. SHO-60-155338 describes and claims a more simplified tool changer. It teaches tool transfer between the tool magazine and the spindle by cam and crank mechanisms actuated by the travel of the spindlehead toward and away from the work. However, for the indexing of the tool magazine, this prior art tool changer employs a fluid actuator devoted exclusively to that purpose. The fluid actuator requires a valve, which may be solenoid operated, for incrementally revolving the tool magazine. Each time the tool magazine is incremented, the operation of the solenoid valve must be checked to make sure that the magazine has been driven a unit distance. Such fluid operated indexing of the tool magazine is not so reliable in operation and quick in response as the cam operated tool transfer between the tool magazine and the spindle.

Another inconvenience with the noted prior art tool changer manifests itself during the continuous indexing of the tool magazine. Each cutting tool is held by a pair of gripping jaws on the tool magazine and is released therefrom by a finger acting directly on the gripping jaws. The release finger is held close to the gripping jaws during the continuous indexing of the tool magazine. Consequently, in the event of the malfunctioning of the electrical control means, the release finger may strike a tool on the magazine, possibly dropping the tool therefrom or destroying the magazine.

SUMMARY OF THE INVENTION

The present invention aims at the provision of a machine tool incoporating an automatic tool changing mechanism that is more positive and troubleproof in construction, more reliable in operation, and quicker in response than heretofore.

In summary, the invention provides a machine tool for use with a plurality of cutting tools, comprising a spindlehead mounted to frame means for linear reciprocation in a predefined direction, and a spindle mounted to the spindle for rotation about an axis extending in the predefined direction of movement of the spindlehead. The spindle travels with the spindlehead between a machining position and a retracted position past a tool change position. Mounted to the frame means for rotation about an axis at an angle to the spindle axis is an indexing tool magazine carrying a set of cutting tools at prescribed angular spacings. As the tool magazine is indexed, the successive cutting tools can be brought to a position of axial alignment with the spindle for engagement in a tool hole therein with the travel of the spindle from the retracted to the tool change position.

For automatically changing the cutting tool mounted to the spindle with those on the tool magazine, there are provided a chuck control cam and a gripper control cam which are both rotatably mounted to the frame means. The chuck control cam operates in conjunction with chuck control cam follower means for acting on chuck means built into the spindle, causing the chuck means to chuck and unchuck the successive cutting tools on the tool magazine in the tool change position. The gripper control cam coacts with gripper control cam follower means for acting on gripper means releasably gripping each cutting tool on the tool magazine, causign the gripper means to release each desired cutting tool that has been chucked onto the spindle in the tool change position, and to grip the used cutting tool that has been returned with the spindle from the machining position to the tool change position.

In order to drive the automatic tool changer, there is employed but one rotary actuator which is coupled to either one of the chuck control cam and the gripper control cam. A mechanical drive linkage transmits rotation from said one to the other of the chuck control cam and the gripper control cam. A mechanical intermittent drive means is also driven from the rotary actuator and coupled to the tool magazine for indexing the same in relation to the joint rotation of the chuck control cam and the gripper control cam.

In a preferred embodiment the rotary actuator is coupled to the chuck control cam for directly driving the same. The rotation of the chuck control cam is transmitted to the gripper control cam via a belt and sprocket arrangement employed as an example of the mechanical drive linkage. The rotation of the gripper control cam is transmitted in turn to the tool magazine via the intermittent drive means of conventional design capable of revolving the tool magazine a unit indexing angle upon 180 degrees rotation of the gripper control cam.

Thus, with not only the two cams but also the tool magazine driven from the common actuator, the improved tool changer of this invention fully attains the objects set forth previously.

The above and other features and advantages of this invention and the manner of realizing them will become more apparent, and the invention itself will best be understood, from a study of the following description and appended claims, with reference had to the attached drawings showing the preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partial vertical section through an example of machine tool incorporating the automatic tool changer constructed in accordance with the invention;

FIG. **2** is a horizontal section through the machine tool;

FIG. **3** is a fragmentary, enlarged plan view, with parts shown in section for clarity, of the machine tool, showing in particular the chuck control cam and associated cam follower means;

FIG. **4** is an elevation of the showings of FIG. **3**;

FIG. **5** is an enlarged plan view, with parts shown in section for clarity, of one of the pairs of gripper jaws relesably holding the cutting tools on the tool magazine shown in FIGS. **1** and **2**, shown together with a push finger for opening the gripper jaws;

FIG. **6** is an enlarged elevation, with parts shown in section for clarity, of the gripper control cam and associated cam follower means of the machine tool;

FIGS. 7A–7H is a series of diagrammatic representations of the machine tool, each somewhat similar to FIG. **1**, showing a sequence of steps in one complete cycle of tool changing operation by the automatic tool changer; and

FIG. **8** is a timing chart summarizing the tool changing steps of FIG. 7A–7H in relation to one complete revolution of the chuck control cam and the gripper control cam.

DESCRIPTION OF THE PREFERRED EMBODIMENT

General

The invention will now be described more specifically in terms of the illustrated representative machine tool, generally designated **10** in FIGS. **1** and **2**, including an automatic tool changer **12**. The machine tool **10** has frame means including a column **14** to which a spindlehead **16** is mounted so as to be movable up and down relative to the column. For the up and down motion of the spindlehead **16** this embodiment conventionally employs an upstanding worm **18** and a ball nut assembly **20**. The worm **18** is rotatably mounted to the column **14** and is coupled to an overlying bidirectional servomotor **22**. Fitted over the worm **18**, the ball nut assembly **20** is rigidly mounted to the spindlehead **16**. Thus, with the bidirectional rotation of the worm **18** with the servomotor **22**, the ball nut assembly **20** travels up and down with the spindlehead **16**.

As shown also in FIGS. **1** and **2**, a hollow spindle **24** is vertically mounted to the spindlehead **16** for rotation parallel to the axis of the worm **18**. The spindle **24** travels up and down with the spindlehead **16** between a lower machining position (FIG. 7A) and an upper retracted position (FIG. 7E) past a tool change position (FIG. 7B) midway between the machining and retracted positions. FIG. **1** also depicts the spindle **24** in the tool change position. A second servomotor **26** is mounted atop the spindlehead **16** and drivingly coupled to the spindle **24** for imparting rotation thereto during machining. The servomotor **26** can arrest the rotation of the spindle **24** in a preassigned angular position. A chuck **28** of any known or suitable construction is built into the spindle **24** for rigidly but releasably holding a cutting tool on its bottom end.

The automatic tool changer **12** includes an indexing tool magazine **30** rotatable about an axis at an angle to the axis of the spindle **24**. The tool magazine **30** carries a set of arbored cutting tools, two seen at **32** in FIG. **1**, disposed at prescribed angular spacings about the tool magazine axis. The cutting tools **32** are mounted in such an attitude on the tool magazine **30** that each tool can be brought to a position of axial alignment with the spindle **24** as the magazine is indexed. A pair of gripper jaws **34** on the tool magazine **30** releasably grips each cutting tool **32** in position thereon. When actuated by means set forth hereafter, each pair of gripper jaws **34** spread apart to permit the associated cutting tool to be mounted to the spindle **24**, or to accept the used cutting tool from the spindle.

Also included in the automatic tool changer **12** is a chuck control cam **36**, shown also in FIGS. **3** and **4**, mounted to a U shaped frame member **38** on the column **14** for rotation about a horizontal axis. Driven by a tool changer drive motor **40**, the chuck control cam **36** acts, via associated cam follower means, to operate the spindle chuck **28** during the mounting and dismounting of the successive cutting tools **32** to and from the spindle **24**.

Another important component of the automatic tool changer **12** is a gripper control cam **42** rotatable about an axis parallel to the axis of rotation of the chuck control cam **36**. The gripper control cam **42** is provided with follower means acting on one of the pairs of gripper jaws **34** on the tool magazine **30** for spreading them apart during tool transfer between spindle **24** and tool magazine **30**.

Not only the chuck control cam **36** but also the gripper control cam **42** and the tool magazine **30** are driven from the tool changer drive motor **40** via purely mechanical means in accordance with a feature of the invention.

The following is a more detailed discussion of the spindle **24** with its chuck **28**, the tool magazine **30**, the chuck control cam **36** with its follower means, the gripper control cam **42** with its follower means, and the tool changer drive motor **40** and associated drive means, under the separate headings. The operational description of the complete tool changer **12** will follow the detailed discussion of the listed components.

Spindle and Chuck Assembly

With reference to FIG. **1** the spindle **24** has a tapered tool hole **44** formed coaxially in its bottom end for receiving the arbor **46** of each cutting tool **32**. The spindle chuck **28** includes a draw-in bar **48** received coaxially in the hollow of the spindle **24** with substantial clearance for up and down movement relative to the spindle. The draw-in bar **48** carries on its bottom end a pair of chucking jaws **50** for chucking engagement with a pull stud **52** extending upwardly or rearwardly from the taper shank of the arbor **46** of each cutting tool **32**. Sleeved upon the draw-in bar **48**, a disc spring assembly **54** biases the bar upwardly. Normally, therefore, the spindle chuck **28** is conditioned to firmly hold the cutting tool **32** with its jaws **50**. The draw-in bar **48** has its top end embedded in a slidable member **56**.

As will be seen also from FIG. **4**, the slidable member **56** is rigidly joined via a pin **58** to a sleeve **60** slidably fitted over the spindle **24**. The pin **58** slidably extends through a pair of slots **62** formed in diametrically opposed positions in the spindle **24** and extending parallel to the spindle axis. It will therefore be seen that the sleeve **60** is movable up and down with the draw-in bar **48** relative to the spindle **24**. The sleeve **60** is to be

depressed by the follower means of the chuck control cam **36** against the force of the disc spring assembly **54** for unchucking the tool from the spindle **24**, as will be later described in more detail.

Tool Magazine

As shown in both FIGS. **1** and **2**, the tool magazine **30** is rotatably mounted to a distal end of a support frame **64** which is proximally anchored to the column **14** and which defines a space **66** for accommodating the spindlehead **16** and other parts of the machine. The tool magazine **30** is generally in the shape of a disk formed in one piece with a central shaft **68** journaled to the support frame **64** for rotation about an axis slanting downwardly as it extends away from the spindlehead **16**. The disklike tool magazine **30** has a flaring rim **70** whose lowermost part, as seen in FIG. **1**, is contained in a plane right angularly crossing the spindle axis just under the spindle **24** when the latter is in the tool change position. The set of cutting tools **32** are releasably held by the respective pairs of gripper jaws **34** at predetermined tool stations on the flaring rim **70**, such tool stations being disposed at constant angular spacings about the slanting axis of the tool magazine **30**.

FIG. **5** best illustrates one of the pairs of gripper jaws **34** releasably holding the cutting tools **32** on the flaring rim **70** of the tool magazine **30**, it being understood that the other pairs of gripper jaws are of like construction. Pivoted at **72** on the tool magazine rim **70**, the representative pair of gripper jaws **34** are urged toward each other by a helical tension spring **74** for gripping the associated cutting tool **32** at its arbor **46**. The pair of gripper jaws **34** are to be pivoted away from each other against the force of the tension spring **74** by the follower means of the gripper control cam **42** to be set forth subsequently, whereupon the cutting tool **32** will be released.

For imparting rotation to the tool magazine **30** there is employed an intermittent drive mechanism **76** coupled to a shaft **78** on which the gripper control cam **42** is fixedly mounted. Although the detailed construction of the intermittent drive mechanism **76** is not illustrated because of its conventional nature, it is understood that this mechanism comprises cams and rollers so arranged that its output shaft **80** rotates a unit indexing angle with each 180 degrees rotation of the gripper control cam shaft **78**.

The output shaft of the intermittent drive mechanism **76** has a drive pinion **82** mounted fast thereon. The drive pinion **82** meshes with a driven gear **84** which is rigidly mounted on the tool magazine shaft **68**. It is thus seen that the tool magazine **30** is mechanically driven directly from the gripper control cam shaft **78**, which in turn is driven from the tool changer drive motor **40** via means that will become apparent as the description proceeds. The angle of each increment of rotation of the intermittent drive mechanism **76** and the speed reduction ratio of the drive pinion **82** and driven gear **84** depend upon the unit indexing angle of the tool magazine **30**, that is, upon the number of tool stations on the tool magazine.

Chuck Control Cam and Follower Means

The chuck control cam **36** and the associated cam follower means are shown in FIGS. **1** and **2** and on an enlarged scale in FIGS. **3** and **4**. The chuck control cam **36** is fixedly mounted on a camshaft **86** which is rotatably and horizontally mounted to the frame member **38** and which is coupled directly to the tool changer drive motor **40**. As indicated in FIG. **4**, the chuck control cam **36** is peripherally contoured to provide a larger diameter portion **88** and a reduced diameter portion **90**, with a relatively small protuberance **92** formed in the middle of the reduced diameter portion **90**.

At **94** is seen a chuck control cam follower lever which is proximally mounted fast on a rotatable shaft **96** which in turn is mounted horizontally to the spindlehead **16**. The cam follower lever **94** rotatably carries a roll **98** on its distal end for rolling engagement with the contoured periphery of the chuck control cam **36**. Thus the shaft **96** rotates as the chuck control cam **36** rotates in rolling contact with the roll **98** on the cam follower lever **94**.

Medially mounted fast on the shaft **96**, an unchucking arm **100** has a bifurcated end, best seen in FIG. **2**, overlying the slide sleeve **56** on the spindle **24**. The cam follower lever **94** will turn in a counterclockwise direction, as viewed in FIG. **1**, as the roll **98** thereon rides on the larger diameter portion **88** of the chuck control cam **36** as in FIG. **4**. Thereupon, with the rotation of the shaft **96** in the same direction, the unchucking arm **100** thereon will depress the slide sleeve **56** thereby opening the chuck **28**. As shown in both FIGS. **1** and **4**, a helical tension spring **102** extends between the other end of the unchucking arm **100** and the spindlehead **16** for urging the cam follower lever **94** into rolling engagement with the chuck control cam **36**. A limit stop **104** on the spindlehead **16** is engageable with the unchucking arm **100** for limiting the pivotal motion of the cam follower lever **94** under the force of the tension spring **102** when the roll **98** thereon comes to ride on the protuberance **92** of the chuck control cam **36**.

As clearly revealed by both FIGS. **3** and **4**, another limit stop **106** is rigidly fastened to the frame member **38**. The limit stop **106** has mounted thereto a roll **108** rotatable about an axis parallel to that of the shaft **96**. Engageable with this stop roll **108** is a contact member **110** which is secured to the free end of the cam follower lever **94** and which has an approximately vertically elongated contact surface **112** for direct contact with the stop roll **108**. The limit stop **106** with the roll **108** coacts with the contact member **110** for holding the cam follower lever **94** in the angular position of FIG. **4** with respect to the chuck control cam **36** when the spindlehead **16** with the spindle **24** and cam follower lever **94** thereon is located above the tool change position of FIG. **1**

Gripper Control Cam and Follower Means

Although FIGS. **1** and **2** both show the gripper control cam **42** and the associated cam follower means, FIG. **6** better illustrates that the gripper control cam **42** is generally in the shape of a disc keyed to the noted shaft **78** and having a substantially annular cam groove **114** formed in one of its opposite faces. The cam groove **114** has a reduced diameter portion **116**. Rollably engaged in the cam groove **114** is a roll **118** on one end of a cam follower lever **120** which is secured at the other end to a shaft **122**. This shaft **122** is mounted to the support frame **64** for rotation about an axis parallel to that of the gripper control cam shaft **78**.

An inspection of both FIGS. **2** and **6** will reveal that a carrier arm **124** is also rigidly mounted on the shaft **122** and extends downwardly therefrom for joint angular displacement with the cam follower lever **120**. The carrier arm **124** is bifurcated at **126**, FIG. **6**, and slidably

carries between its two constituent parts a tool release arm **128** in collinear relation thereto. The tool release arm **128** has formed therein a pair of guide slots **130** spaced from each other, and each extending, in its longitudinal direction. Each guide slot **130** slidably receives a guide pin **132** having its opposite ends rigidly anchored to the two parts of the bifurcated carrier arm **124**. Thus the tool release arm **128** is constrained to linear displacement relative to the carrier arm **124** in its longitudinal direction but is pivotable with the carrier arm about the shaft **122** as the cam follower lever **122** is pivoted by the gripper control cam **42**. Extending downwardly beyond the lower extremity **134** of the carrier arm **124**, the tool release arm **128** terminates in a push finger **136** bent approximately right angularly therefrom toward the spindle **24**.

As best seen in FIG. **5**, the push finger **136** is held opposite the overlapping extensions **138** of that pair of gripper jaws **34** on the tool magazine **30** which has been indexed to the tool change position of the spindle **24**. When the roller **118** on the cam follower lever **120** rides in the reduced diameter portion **116** of the gripper control cam groove **114**, the push finger **136** will be thrusted against the gripper jaw extensions **138** thereby spreading the pair of gripper jaws **34** against the force of the tension spring **74** with the consequent release of the cutting tool **32**.

With reference back to FIG. **6** in particular a generally upstanding draw bar or stud **140** slidably extends through a hole **142** formed diametrally in the shaft **122**. The bottom end of the draw bar **140** is firmly embedded in the tool release arm **128** whereas its top end is bent toward the spindlehead **16** to provide a hook **144**. Engageable with the hook **144** is a ledge **146** formed on the spindlehead **16** by fastening an L shaped member thereto as better shown in FIG. **1**. A helical compression spring **148** extends between the shaft **122** and the top end of the tool release arm **128**.

Normally, as indicated by the solid lines in FIG. **6**, the compression spring **148** holds the tool release arm **128** lowered with respect to the bifurcated carrier arm **124**. Upon upward travel of the spindlehead **16** the ledge **146** thereon will engage the hook **144** of the draw bar **140** and pull the tool release arm **128** upwardly against the force of the compression spring **148** in order to avoid interference of the push finger **136** with the tool magazine **30**.

Tool Changer Drive Means

As has been stated, the various moving parts of the automatic tool changer **12** are all driven from the tool changer drive motor **40** seen in FIGS. **2** and **3**. The tool changer drive motor **40** directly drives the chuck control cam **36** via the shaft **86**. The rotation of the shaft **86** is further imparted to the gripper control cam **42** via a positive drive linkage which in this embodiment is shown as a chain drive. As shown also in FIG. **1**, an endless chain **150** extends between a drive sprocket **152** on the chuck control cam shaft **86** and a driven sprocket **154** on the gripper control cam shaft **78**. The two sprockets **152** and **154** are of the same diameter, so that the chuck control cam **36** and gripper control cam **42** are driven at the same rate.

The gripper control cam shaft **78** is drivingly coupled to the shaft **68** of the indexing tool magazine **30** via the mechanical intermittent drive assembly **76** and gears **82** and **84**, as has been set forth in conjunction with the tool magazine.

Operation

One cycle of tool changing operation by the automatic tool changer **12** will become apparent from a study of FIGS. **1** and 7A–7H which sequentially illustrate the steps of such cycle. Reference may also be had to FIG. **8** which diagrammatically summarizes the operation of the automatic tool changer **12**, indicating the angular positions of the chuck control cam **36**, gripper control cam **42** and the tool magazine **30**.

FIG. **1** represents the machine tool **10** in a state such that a first of the series of cutting tools **32** on the tool magazine **30** has just been chucked onto the spindle **24** in the tool change position. The tool changer drive motor **40** is out of rotation, with the chuck control cam **36** in such an angular position that the roll **98** on the cam follower lever **94** rides on the small protuberance **92** in the middle of the reduced diameter portion **90** of the chuck control cam **36**. The unchucking arm **100** is pivoted away from the slide sleeve **60** on the spindle **24** under the bias of the tension spring **102**, thereby permitting the chuck jaws **50** to engage the first cutting tool **32** under the force of the disc spring assembly **54**. The gripper control cam **42** is in such an angular position that the roll **118** on the cam follower lever **120** is in the reduced diameter portion **116** of the cam groove **114**. Consequently, the tool release arm **128** is pivoted counterclockwise with the carrier arm **124**, as indicated by the solid lines in FIG. **6**, with the result that the pair of gripper jaws **34** being held in the tool change position are opened by the push finger **136** against the force of the tension spring **74**. Thus the first cutting tool **32** has been chucked onto the spindle **24** and released by the associated pair of gripper jaws **34**.

FIG. **8** indicates these start positions of the chuck control cam **36** and gripper control cam **42** at A.

The machine tool being now ready for machining with the first cutting tool, the servomotor **22** may be set into rotation in a required direction for lowering the spindle **24** to the machining position. FIG. 7A shows the spindle **24** thus lowered to the machining position. It will be seen that the chuck control cam **36** and the gripper control cam **42** are left standing by in the same angular positions as in FIG. **1** during the subsequent progress of machining. The servomotor **26** on the spindlehead **16** is energized to impart rotation to the sindle **24** during such machining.

Upon completion of machining with the first cutting tool the servomotor **22** may be set into rotation in the reverse direction for lifting the spindle **24** back to the tool change position of FIG. **1** with the spindlehead **16**. Since the chuck control cam **36** has been at a standstill, the roll **98** on the cam follower lever **94** will ride back on the small protuberance **92** of the cam **36** as the spindle **24** returns to the tool change position.

In FIG. 7B are shown the chuck control cam **36** and gripper control cam **42** subsequently revolved approximately 20 degrees in a clockwise direction from its FIGS. **1** and 7A position to the position B in FIG. **8**. The cam follower roll **98** is still on the reduced diameter portion **90** of the chuck control cam **36**. Accordingly, the unchucking arm **100** remains out of contact with the slide sleeve **60** on the spindle **24**, holding the first cutting tool **32** chucked to the spindle. However, the angular position of the gripper control cam **42** is such that the cam follower roll **118** has already ridden onto the larger diameter portion of the cam groove **114**. With the consequent clockwise turn of the tool release arm **128**

with the carrier arm **124**, the push finger **136** has moved out of contact with the extensions **138** of the pair of gripper jaws **34**, permitting the latter to pivot toward each other under the force of the tension spring **74** and hence to grip the first cutting tool **32** therebetween.

FIG. 7C shows the chuck control cam **36** subsequently revolved to the position C in FIG. **8**, in which the cam follower roll **98** start riding on the larger diameter portion **88** of the chuck control cam. As the cam follower lever **94** is thus turned counterclockwise against the effect of the tension spring **102**, the bifurcated unchucking arm **100** will engage and depress the slide sleeve **60** with respect to the spindle **24** against the force of the disc spring assembly **54**. With the simultaneous downward displacement of the draw-in bar **48**, the spindle chuck **28** will open to disengage the first cutting tool **32**. The pair of gripper jaws **34** in the tool change position will remain gripping the first cutting tool **32** as the cam follower roll **118** still lies in the larger diameter portion of the gripper control cam **42**.

The tool changer drive motor **40** is temporarily set out of rotation after the cams **36** and **42** are subsequently revolved approximately 20 degrees to the position D in FIG. **8**. FIG. 7D represents this state. The first cutting tool **32** remains unchucked from the spindle **24** and gripped by the pair of gripper jaws **34**.

Then, with the tool changer drive motor **40** held out of rotation, the servomotor **22** is again set into rotation in the reverse direction for raising the spindle **24** to the retracted position of FIG. 7E. This retracted position is so determined in relation to the tool change position that the unchucked cutting tool **32** is thoroughly withdrawn from the spindle **24** when the latter reaches the retracted position.

During the ascent of the spindle **24** from the tool change position of FIG. 7D to the retracted position of FIG. 7E, the ledge **146** on the spindlehead **16** will engage the hook **144** of the draw bar **140** anchored to the tool release arm **128**. The draw bar **140** will then draw the tool release arm **128** to the phantom position of FIG. **6** against the force of the tension spring **148**. Such retraction of the tool release arm **128** with its push finger **136** is needed to avoid its interference with the gripper jaws **34** during the subsequent indexing of the tool magazine **30**.

It will also be noted from FIG. 7E that the contact member **110** on the chuck control cam follower lever **94** comes into rolling engagement with the limit stop **106** on the frame member **38** via the roll **108** when the spindle **24** is in the retracted position. Therefore, even though the roll **98** on the cam follower lever **94** has ridden off the chuck control cam **36**, the lever **94** will remain in the same angular position as when the roll **98** is on the larger diameter portion **88** of the cam **36**. The spindle chuck **28** will thus be held open when the spindle **24** is in the retracted position.

Then, with the spindle **24** held retracted, the tool changer drive motor **40** may again be set into rotation for jointly revolving the chuck control cam **36** and gripper control cam **42** through an angle of 180 degrees from the position D to the position F in FIG. **8**. FIG. 7F shows the resulting state of the machine. Attention should be paid not only to the angular positions of the cams **36** and **42** but also to that of the tool magazine **30**. Driven from the gripper control cam shaft **78** via the intermittent drive mechanism **76** and the gears **82** and **84**, the tool magazine **30** has been indexed through an angle required for brining the second desired cutting tool **32** to the position of axial alignment with the spindle **24** being held in the retracted position. The tool changer drive motor **40** comes to another stop after the 180 degrees rotation.

Then the servomotor **22** is again energized for lowering the spindle **24** from the retracted to the tool change position, with the cams **36** and **42** and tool magazine **30** maintained in the positions of FIG. 7F. The spindle **24** when lowered to the tool change position will receive the arbor **46** of the second cutting tool **32** in its tapered tool hole **44**. Also, as the spindlehead **16** is lowered with the spindle **24**, the roll **98** on the cam follower lever **94** on the spindlehead will reengage the chuck control cam **36** at its larger diameter portion **88**. The unchucking arm **100** will therefore be still acting on the slide sleeve **60** on the spindle **24** against the force of the tension spring **102**, holding the spindle chuck **28** open.

Further, with the above descent of the spindle **24** from the retracted to the tool change position, the draw bar **140** will be disengaged from the ledge **146** on the spindlehead **16**, permitting the tool release arm **128** to be lowered to its working position with respect to the bifurcated carrier arm **124** under the force of the compression spring **148**. However, the roll **118** on the cam follower lever **120** is still on the larger diameter portion of the gripper control cam **42**. Since the push finger **136** of the tool release arm **128** will thus be held away from the gripper jaw extensions **138**, the second cutting tool **32** will remain gripped on the tool magazine **30** even though it has had its arbor **46** received as aforesaid in the tool hole **44** of the spindle **24**.

Then the tool changer drive motor **40** may be reenergized for revolving the cams **36** and **42** approximately 20 degrees from the position F to position G in FIG. **8**. FIG. 7G shows the resulting state. It will be observed that the cam follower roll **98** is still on the larger diameter portion **88** of the chuck control cam **36**, holding the spindle chuck **28** open. The gripper control cam **42** is still in such an angular position that the second cutting tool **32** will remain gripped on the tool magazine **30**.

Then, with the continued energization of the tool changer drive motor **40**, the cams **36** and **42** are revolved from the position G to position H in FIG. **8**. Now, as will be noted from FIG. 7H, the cam follower roll **98** has ridden back onto the reduced diameter portion **90** of the chuck control cam **36**. The cam follower lever **54** will then turn clockwise under the bias of the tension spring **102**. Upon consequent disengagement of the unchucking arm **100** from the slide sleeve **60** on the spindle **24**, the spindle chuck **28** will firmly engage the second cutting tool **32** under the force of the disc spring assembly **54**. The gripper control cam **42**, on the other hand, is still in such an angular position that the second cutting tool **32** will remain gripped on the tool magazine **30**.

Then, with the further continued energization of the tool changer drive motor **40**, the cams **36** and **42** are revolved from the position H back to the initial position A in FIG. **8**. The machine tool **10** has now returned to the state of FIG. **1**. The tool changer drive motor **40** may be set out of rotation. As will be seen by referring back to FIG. **1**, the cam follower roll **118** rides on the reduced diameter portion **116** of the gripper control cam **114**, with the result that the push finger **136** of the tool release arm **128** pushes the extensions **138** of the gripper jaw pair **34** in the tool change position thereby causing the same to release the second cutting tool **32**.

The machine tool **10** is now ready for the commencement of machining with the second cutting tool. The spindle **32** with the second cutting tool chucked thereto may be depressed to the machining position, as in FIG. 7A, for the next cycle of operation.

While there has been disclosed what is presently believed to be a preferable embodiment of the invention, it will be understood that various modifications may be made in such disclosure to conform to design preferences or to the requirements of specific applications of the invention. The appended claims are intended to cover all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a machine tool for use with a plurality of different cutting tools, in combination:

(a) frame means;

(b) a spindlehead mounted to the frame means for linear reciprocating movement relative to the same in a predefined direction;

(c) a spindle mounted to the spindlehead for rotation relative to the same about a first axis extending in the predefined direction of movement of the spindlehead and having a tool hole defined coaxially in one end thereof, the spindle traveling with the spindlehead between a machining position and a retracted position past a tool change position;

(d) an indexing tool magazine mounted to the frame means for rotation relative to the same about a second axis at an angle to the first axis, the tool magazine carrying a set of cutting tools at prescribed angular spacings about the second axis and in such an attitude that, with the rotation of the tool magazine, each cutting tool can be brought to a position of axial alignment with the spindle for engagement in the tool hole therein with the travel of the spindle from the retracted to the tool change position;

(e) chuck means built into the spindle for releasably holding the cutting tool engaged in the tool hole;

(f) a chuck control cam rotatably mounted to the frame means;

(g) chuck control cam follower means acted upon by the chuck control cam and acting on the chuck means for causing the same to chuck and unchuck the successive cutting tools on the tool magazine in the tool change position;

(h) gripper means on the tool magazine for releasably gripping each cutting tool thereon;

(i) a gripper control cam rotatably mounted to the frame means;

(j) gripper control cam follower means acted upon by the gripper control cam and acting on the gripper means for causing the same to release each new cutting tool that has been chucked onto the spindle in the tool change position, and to grip the used cutting tool that has been returned with the spindle from the machining position to the tool change position;

(k) a rotary actuator for imparting rotation to either one of the chuck control cam and the gripper control cam;

(l) a mechanical drive linkage for transmitting rotation from said one to the other of the chuck control cam and the gripper control cam; and

(m) mechanical intermittent drive means driven from the rotary actuator and coupled to the tool magazine for indexing the same in relation to the joint rotation of the chuck control cam and the gripper control cam;

(n) whereby the chuck control cam, the gripper control cam and the tool magazine are all driven mechanically from the single rotary actuator in precise synchronism with one another.

2. The machine tool of claim **1** wherein the rotary actuator is coupled to the chuck control cam for directly driving the same, and wherein the gripper control cam is driven from the chuck control cam via the mechanical drive linkage.

3. The machine tool of claim **2** wherein the intermittent drive means is connected between the gripper control cam and the indexing tool magazine.

4. The machine tool of claim **1** wherein the chuck control cam follower means comprises:

(a) a cam follower lever pivotally mounted to the spindlehead and operatively engaged with the chuck control cam when the spindle is in the tool change position; and

(b) resilient means on the spindlehead for biasing the cam follower lever into operative engagement with the chuck control cam;

(c) the cam follower lever being pivoted with the rotation of the chuck control cam between a chucking position for causing the chuck means to engage one of the cutting tools and an unchucking position for causing the chuck means to release the cutting tool.

5. The machine tool of claim **4** wherein the chuck control cam follower means further comprises a limit stop mounted to the frame means and engageable with the cam follower lever upon displacement of the spindle from the tool change position toward the retracted position in order to maintain the cam follower lever in the unchucking position while the cam follower lever is out of engagement with the chuck control cam.

6. The machine tool of claim **4** wherein the chuck control cam follower means further comprises:

(a) a slide sleeve coupled to the chuck means and fitted over the spindle for axial displacement relative to the same; and

(b) an unchucking arm pivotable jointly with the cam follower lever for movement into and out of engagement with the slide sleeve, the unchucking arm acting on the slide sleeve for opening the chuck upon pivotal movement of the cam follower lever from the chucking to the unchucking position.

7. The machine tool of claim **1** wherein the gripper control cam follower means comprises:

(a) a cam follower lever pivotally mounted to the frame means and operatively engaged with the gripper control cam in order to be pivoted thereby; and

(b) arm means mounted to the frame means for joint pivotal motion with the cam follower lever into and out of engagement with the gripper means.

8. The machine tool of claim **7** wherein the arm means of the gripper control cam follower means comprises:

(a) a carrier arm rigidly coupled to the cam follower lever for joint pivotal motion therewith;

(b) a tool release arm mounted to the carrier arm for joint pivotal motion therewith while being displaceable relative to the carrier arm between a working position and a non-working position, the tool release arm when in the working position

being pivotable with the carrier arm into and out of engagement with the gripper means;

(c) resilient means for holding the tool release arm in the working position with respect to the carrier arm at least when the spindle is in the tool change position; and

(d) means for moving the tool release arm from the working to the nonworking position against the force of the resilient means upon movement of the spindle from the tool change position to the retracted position in order to avoid interference of the tool release arm with the gripper means during the indexing of the tool magazine.

9. The machine tool of claim **8** wherein the tool release arm is mounted collinearly to the carrier arm and constrained to longitudinal displacement relative to the latter between the working and nonworking positions, and wherein the means for moving the tool release arm comprises:

(a) a draw bar anchored at one end to the tool release arm; and

(b) engagement means on the spindlehead engageable, upon movement of the spindle from the tool change position toward the retracted position, with another end of the draw bar for moving the tool release arm from the working to the nonworking position against the force of the resilient means.

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United States Patent [19]

Miyano

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[45] Date of Patent: Mar. 31, 1992

[54] SUBMERGED WORK MACHINE TOOL

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[73] Assignee: Miyano Machinery USA Inc., Wood Dale, Ill.

[21] Appl. No.: 679,635

[22] Filed: Apr. 2, 1991

[51] Int. Cl.[5] B23B 13/00; B23H 1/00; B23Q 11/12

[52] U.S. Cl. 82/124; 82/900; 219/69.11; 29/DIG. 71; 51/235; 51/266; 51/356; 269/13

[58] Field of Search .... 82/117, 1.11, 124, 900, 82/901, 173; 409/225, 135, 136; 279/3; 29/DIG. 71, DIG. 50, DIG. 53, DIG. 68, DIG. 77; 204/297 M; 219/69.11, 69.15, 69.17; 51/235, 266, 356; 269/13, 14, 21

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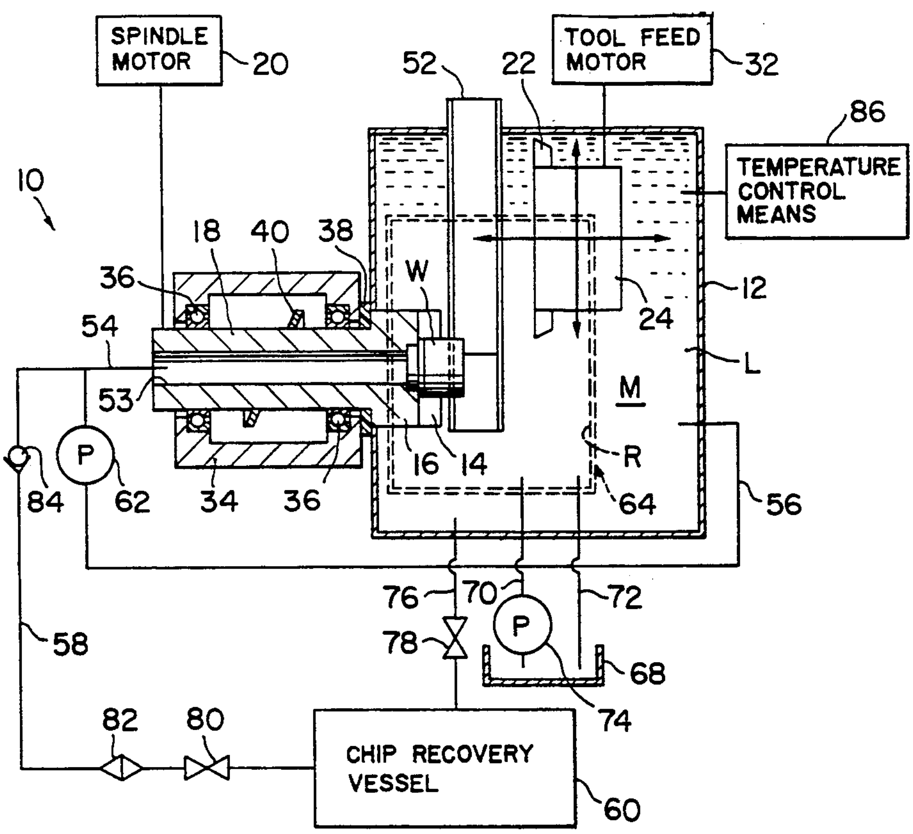
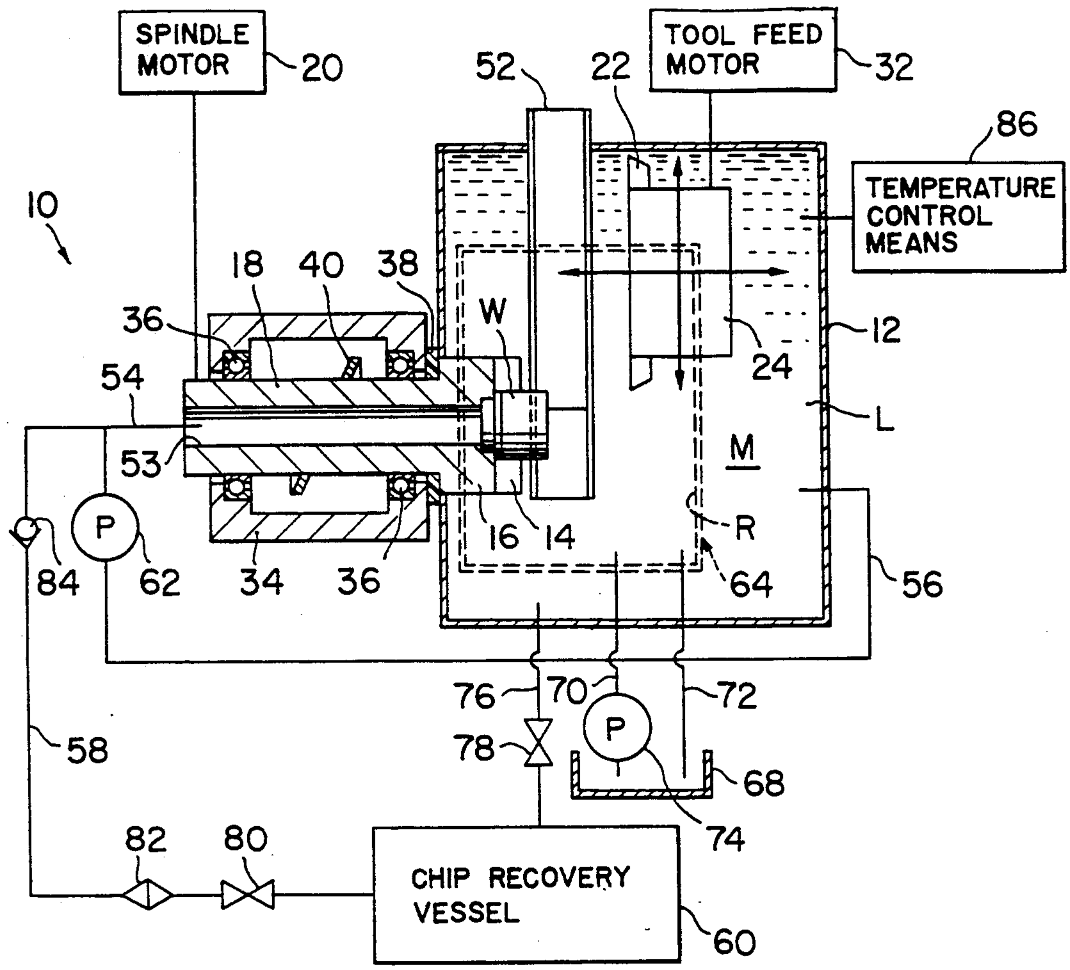
Assistant Examiner—Kevin J. Carroll
Attorney, Agent, or Firm—Ladas & Parry

[57] ABSTRACT

A machine tool has a hollow drive spindle with a work holder attached thereto for holding work submerged in a machine liquid, such as mineral oil, contained in a machining chamber. The work is machined in the submerged state as a cutting tool is fed against the work rotating with the drive spindle. The machining liquid is additonally utilized for hydrodynamically loading the work on the work holder by drawing the liquid from the machining chamber into the hollow in the drive spindle, and for unloading the completed product from the work holder by forcing the liquid back into the machining chamber through the hollow in the drive spindle. A removable chip recovery vessel is provided for the recovery of the metal chips and particles from the machining liquid by recirculating it through the vessel. The machine tool can take various other arrangements for the performance of a variety of cutting operations.

17 Claims, 2 Drawing Sheets

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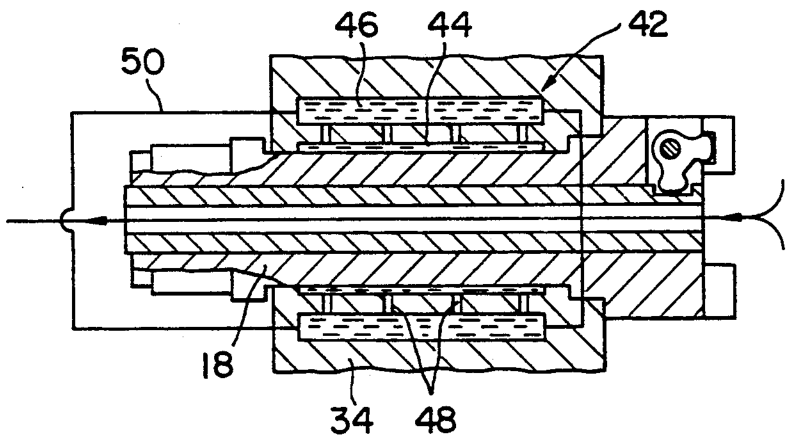
F I G. 1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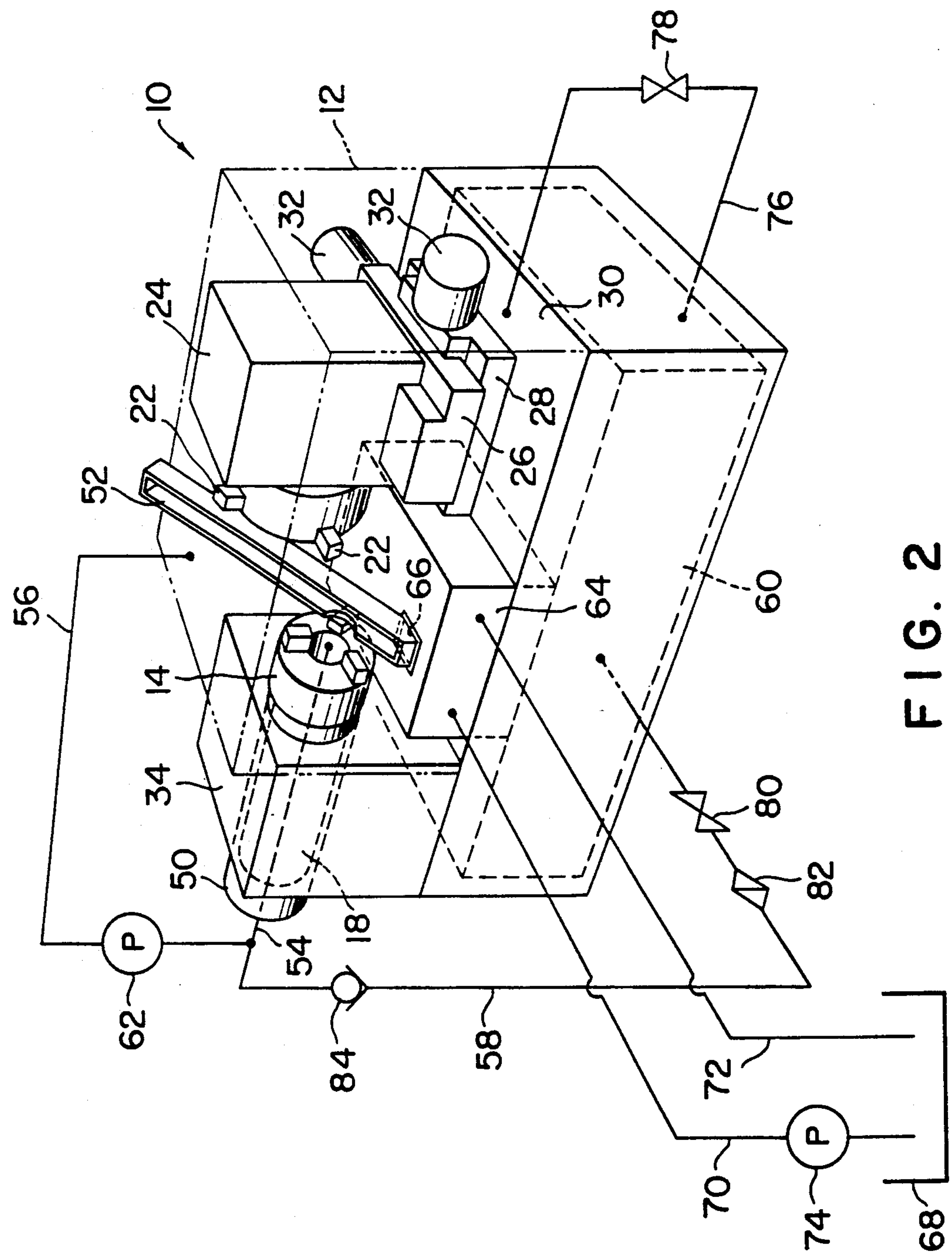
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FIG. 2

SUBMERGED WORK MACHINE TOOL

BACKGROUND OF THE INVENTION

This invention relates to machine tools, and more particularly to those of the kind in which work is machined while being submerged in a body of a machining liquid such as mineral oil or an aqueous solution thereof in the form of an emulsion. Still more particularly, the invention pertains to a streamlined machine tool system including facilities for hydrodynamically loading the work in position and unloading the finished product by utilizing the machining liquid.

Electric discharge machining or electrospark machining represents a conventional art of submerged work machining. It is a process by which materials that conduct electricity are removed from a metal by an electric spark. The discharge machining apparatus has required dedicated mechanical means for the loading and unloading of work as well as for the recovery of the chips or cuttings created by machining. Such mechanical loading and unloading means and chip recovery means have made the complete machining system inordinately bulky in size and expensive in the cost of installation. Indeed, in some instances, the total cost of such additional means has been just as high as that of the apparatus used solely for discharge machining.

Another consideration that should enter into the design of any streamlined machine tooling system is how to make the finished products clean of the chips and particles attached thereto. This is usually done by rinsing the products. The rinsing process comes after the machining process. However, the products need not necessarily be rinsed immediately after having been machined. For this reason the rinsing means have usually been installed separately from the machine tool at the cost of additional space requirement.

SUMMARY OF THE INVENTION

The present invention provides a novel machine tooling system in which work is machined while being submerged in a body of a machining liquid, and in which this liquid is additionally utilized for additional purposes including, but not limited to, the loading of the work and the unloading of the finished product.

Briefly, the present invention may be summarized as a machine tool for machining work with a cutting tool in a submerged state, comprising a liquid tight enclosure defining a machining chamber which is to be filled with a machining liquid and in which work is to be machined in a submerged state. The machine tool further comprises tool holding means for holding a desired cutting tool in the machining chamber, work holding means for holding work in the machining chamber, means for hydrodynamically loading work on the work holding means by utilizing the machining liquid contained in the machining chamber, means for creating relative cutting action between the cutting tool being held by the tool holding means and the work being held by the work holding means in the machining chamber, so that the work is machined into a desired product while being submerged in the machining liquid, and means for hydrodynamically unloading the completed product from the work holding means by utilizing the machining liquid contained in the machining chamber.

In a preferred embodiment, the work to be machined is held by a chuck or like work holder on one end of a drive spindle for joint rotation therewith. A desired cutting tool is fed against the revolving work for cutting the same into a desired shape. The drive spindle has a hollow extending axially therethrough and communicating with the machining chamber. For hydrodynamically loading the work on the work holder and unloading the finished product therefrom, a hydraulic circuit including a reversible pump is provided which permits the bidirectional flow of the machining liquid out of and back into the machining chamber through the hollow in the drive spindle. The machining liquid may be pumped from the machining chamber into the hollow in the drive spindle for loading the work on the work holder, back into the machining chamber through the hollow in the drive spindle for unloading the completed product from the work holder.

No complex mechanical means are therefore required for such loading and unloading operations; only, a simple chute may be provided for introducing the work into the machining chamber and positioning the same in the neighborhood of the work holder on the hollow drive spindle.

The noted reversible pump is additionally utilized for the recovery of metal chips and other solids from the machining liquid by taking advantage of the fact that the hollow in the drive spindle is discommunicated from the machining chamber when the work is held by the work holder. There is provided to this end a second hydraulic circuit including a chip recovery vessel in communication with the machining chamber and with the first recited hydraulic circuit. When the hollow in the drive spindle is closed by the work on the work holder, the pump operates to cause the flow of the machining liquid from the machining chamber into the chip recovery vessel and thence back into the machining chamber via the first hydraulic circuit. The metal chips and other solids are to settle on the bottom of the chip recovery vessel. It will therefore be appreciated that the machining of the work and the recovery of the metal chips take place concurrently.

As a further feature of the invention, means may be provided for controlling the temperature of the machining liquid to suit each specific cutting operation. It is also possible to control the temperature of the complete machine tool through the temperature control of the machining liquid.

A still further feature of the invention resides in means for rinsing the successive products. Such means include another liquid tight enclosure defining a rinsing chamber, and another hydraulic circuit including another pump for recirculating a rinsing liquid out of and back into the rinsing chamber. Advantageously, the rinsing chamber may be disposed immediately under the machining chamber for receiving therefrom the completed product on being unloaded from the work holder. A double hatch may be provided between the rinsing chamber and the machining chamber in order to prevent the intermingling of the rinsing liquid and the machining liquid.

The above and other features and advantages of this invention and the manner of realizing them will become more apparent, and the invention itself will best be understood, from a study of the following description and appended claims, with reference had to the attached drawings showing the preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic representation, partly in section, of the machine tool constructed in accordance with the novel concepts of this invention;

FIG. 2 is a diagrammatic perspective view of the machine tool of FIG. 1; and

FIG. 3 is an axial sectional view showing alternative means for rotatably supporting the hollow drive spindle in the machine tool of FIGS. 1 and 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The submerged work machine tool illustrated in FIGS. 1 and 2 takes the form of a lathe by way of example, although it is readily adaptable for boring or milling as well. Generally designated 10, the illustrated machine tool has a liquid tight enclosure or vessel 12 which is shown filled with a suitable machining liquid L. The enclosure 12 defines a machining chamber M in which the work W is to be machined while being submerged in the body of the liquid L.

Holding the work W in the machining chamber M is a chuck 14, or any equivalent workholder, attached to the nose 16 of a hollow drive spindle 18. The chuck 14 as well as the spindle nose 16 is itself submerged in the liquid L for holding the work W submerged therein. A spindle motor 20 is drivingly coupled to the drive spindle 18 for imparting rotation thereto and hence to the work W held by the chuck 14 on the spindle nose 16.

Also submerged in the liquid L in the machining chamber M are a set of cutting tools 22 on a tool post 24. The cutting tools 22 are disposed opposite the chuck 14 for cutting the work W as the latter is revolved at high speed by the drive spindle 18. The tool post 24 is erected on a cross slide 26. This cross slide is slidably mounted on a saddle 28 which in turn is slidably mounted on a bed 30. Thus the tool post 24 with the cutting tools 22 thereon is movable both in a direction parallel to the axis of the drive spindle 18 and in a direction at right angles with the spindle axis. Servomotors 32 are provided for feeding the toolpost 24 in the two orthogonal directions.

FIG. 1 indicates that the drive spindle 18 is rotatably mounted within a headstock 34 by a pair of rolling element bearings 36. In this case, sealing means may be provided as at 38 in FIG. 1 in order to prevent the leakage of the liquid L from the machining chamber M. Additionally, as required or desired, an impeller 40 may be mounted on the drive spindle 18 for joint rotation therewith. The impeller 40 on rotation at high speed is intended to draw atmospheric air into the headstock 34. The air may be released from within the headstock 34 after having been compressed thereon. So forced into and out of the headstock 34, the air will serve the dual purpose of preventing liquid leakage from the machining chamber M and cooling the drive spindle 18 and other neighboring parts.

Alternatively, a hydrostatic bearing may be employed as indicated at 42 in FIG. 3 for rotatably supporting the drive spindle 18 with respect to the headstock 34. The hydrostatic bearing 42 is shown to have to nested tubular liquid chambers 44 and 46 intercommunicated via radial liquid passageways 48. The inner liquid chamber 44 is formed between drive spindle 18 and headstock 34. The outer liquid chamber 46, concentrically surrounding the inner liquid chamber 44, is defined in the headstock 34. The liquid may be circuited through a hydraulic circuit 50 including the outer liquid chamber 46. Pressurized on being directed into the inner liquid chamber 44, the liquid will hydrostatically support the drive spindle 18 on the headstock 34.

The submerged work machine tool 10 is further constructed for hydrodynamically introducing successive pieces of work W into the machining chamber M, loading them on the chuck 14 on the drive spindle 18, unloading the successive finished products from the chuck, and withdrawing them from the machining chamber. Employed toward this end is a slanting work chute 52 having one end disposed outside the enclosure 12. The work chute 52 extends into the machining chamber M and has its other end held adjacent the chuck 14 on the drive spindle 18.

As has been herein mentioned, the drive spindle 18 has a hollow 53 extending therethrough. In the absence of the work W on the chuck 14, this spindle hollow 53 is open to the machining chamber M on the one hand. On the other hand, the spindle hollow 53 communicates with a conduit 54. This conduit branches into a conduit 56 leading back to the enclosure 12 and another conduit 58 leading to a chip recovery vessel 60. Thus the machining chamber M, the hollow drive spindle 18, and the conduits 54 and 56 form a closed hydraulic circuit for the circulation of the machining liquid L. This hydraulic circuit functions primarily for loading the work W on the chuck 14 on the drive spindle 18 and, after the work has been machined, for unloading the completed product from the chuck.

As the name implies, the chip recovery vessel 60 is intended for the recovery of the metal chips, particles and other solids created by the cutting of the work W by the tools 22, from the machining chamber M. More will be said presently on how the chips are recovered.

A reversible hydraulic pump 62 is provided on the conduit 56. When driven forwardly, the pump 62 will draw the liquid L from the machining chamber M into the hollow 53 in the drive spindle 18. Then the liquid will flow back into the machining chamber M by way of the conduit 56. Driven reversely, on the other hand, the pump 62 will cause the liquid L to flow from the machining chamber M into the conduit 56 and back into the machining chamber through the hollow 53 in the drive spindle 18.

Thus, for loading, the work W may be introduced into the exposed entrance end of the work chute 52, with the pump 62 driven forwardly. Guided by the work chute 52, the work W will fall through the liquid L to the immediate proximity of the chuck 14 on the drive spindle 18. Since now the liquid L is being drawn from the machining chamber M into the hollow 53 in the drive spindle 18 through the chuck 14, the work W will be forced by such liquid flow into the chuck. The chuck 14 may then be closed for tightly gripping the work W in position thereon. The pump 62 may be set out of operation upon completion of work gripping by the chuck 14.

Then the drive spindle 18 may be set into rotation by the spindle motor 20. The cutting tool 22 on the toolpost 24 may be fed against the revolving work W for machining the same into a desired product.

Upon completion of the machining, the chuck 14 may be opened, and the pump 62 may be driven reversely. Then the liquid L will flow from the machining chamber M into the conduit 56 and thence into the hollow 53 in the drive spindle 18. This reverse liquid stream under

pressure will force the completed product out of the open chuck **14**, returning it into the work chute **52**.

The slanting work chute **52** has its exit end held against a removable enclosure **64** defining a rinsing chamber R under the machining chamber M. The rinsing chamber R is to be filled with a rinsing liquid. Normally, a hatch **66** discommunicates the rinsing chamber R from the machining chamber M. Although not clearly seen in the drawings, the hatch **66** is of dual construction in order to prevent the intermingling of the rinsing liquid with the machining liquid L in the machining chamber M. The hatch **66** may be opened each time the finished product, unloaded from the chuck **14**, is positioned on the exit end of the work chute **52**. Then the product will fall into the rinsing chamber R, therein to be cleaned with the rinsing liquid.

The above loading, machining and rinsing cycle may be repeated until any desired number of products are received in the rinsing chamber R. Then the rinsing chamber enclosure **64** may be withdrawn from the machine tool **10** together with the rinsed products contained therein.

At **68** in FIGS. **1** and **2** is shown a reservoir containing the rinsing liquid to be supplied to the rinsing chamber R. A supply conduit **70** and a return conduit **72** communicate the reservoir **68** with the rinsing chamber R. A pump **74** is provided on the supply conduit **70** for recirculating the rinsing liquid through the rinsing chamber R and the reservoir **68**.

The following description is directed to how the chips and other solids, mostly created by the machining of the submerged work, are recovered from the machining liquid L in the machining chamber M. Employed to this end is the noted chip recovery vessel **60**. This vessel communicates directly with the machining chamber M by way of a conduit **76** having an on-off valve **78**. Further, as has been stated, the chip recovery vessel **60** communicates with the noted conduit **58** leading to the reversible pump **62**. Thus another hydraulic circuit is created for the recirculation of the machining liquid L through the chip recovery vessel **60** and the hollow **53** in the drive spindle **18**. The conduit **58** has an on-off valve **80**, a filter **82** and a check valve **84**, arranged in that order from the vessel **60** toward the pump **62**.

In the operation of the chip recovery system constructed as in the foregoing, the pump **62** may be driven forwardly while the work W is being held by the chuck **14** for machining. Since the work W closes the hollow **53** in the drive spindle **18**, the machining liquid L will not flow from the machining chamber M into the drive spindle hollow despite the operation of the pump **62**. Instead, the check valve **84** on the conduit **58** will open to permit liquid flow from the chip recovery vessel **60** into the conduit **58**. This liquid flow will induce in turn the flow of the liquid L from the machining chamber M into the chip recovery vessel **60** by way of the conduit **76**. The metal chips and particles contained in the liquid L will deposit on the bottom of the vessel **60**.

Further, as the pump **62** is driven forwardly as aforesaid, the liquid will flow from the chip recovery vessel **60** into the conduit **58**. The solids that may still be contained in the liquid thus flowing out of the chip recovery vessel **60** will be removed by the filter **82** on the conduit **58**. Then the cleaned liquid will flow through the check valve **84** and the pump **62** and back into the machining chamber M by way of the conduit **56**, bypassing the drive spindle hollow **53** which is now closed by the work W on the chuck **14**.

Thus, in this embodiment of the invention, the single reversible pump **62** serves more purposes than one; namely, the loading and unloading of the work W on and from the chuck **14**, and the recirculation of the machining liquid L through the chip recovery vessel **60** for the recovery of the metal chips and other solids.

The on-off valves **78** and **80** on the conduits **76** and **58** are intended to expedite the withdrawal of the recovered chips from within the recovery vessel **60**. For such withdrawal the valves **78** and **80** may be closed, and the recovery vessel **60** may be disengaged from the conduits **58** and **76**.

As an additional feature of the invention, temperature control means are provided at **86** in FIG. **1**. The temperature control means **86** is intended to control the temperature of the liquid L in the machining chamber M to suit the material of the work W being machined. The temperature control means **86** will serve the additional purpose of controlling the temperature of the complete machine tool **10** through the temperature control of the liquid L.

Although the submerged work machine tool according to the invention has been shown and described hereinbefore in highly specific aspects thereof, it is not desired that the present invention be limited by the exact details of such disclosure. A variety of modifications, alterations and adaptations of the illustrated embodiment will suggest themselves to one skilled in the art in order to conform to design preferences or to the requirements of each specific application of the invention, without departing from the proper scope or fair meaning of the subjoined claims.

What is claimed is:

1. A machine tool for machining work with a cutting tool in a submerged state, comprising:

(a) a liquid tight enclosure for containing a machining liquid, the enclosure defining a machining chamber in which work is to be machined;

(b) tool holding means for holding a desired cutting tool in the machining chamber;

(c) work holding means for holding work in the machining chamber;

(d) means for hydrodynamically loading work on the work holding means by utilizing the machining liquid contained in the machining chamber;

(e) means for creating relative cutting action between the cutting tool being held by the tool holding means and the work being held by the work holding means in the machining chamber, so that the work is machined into a desired product while being submerged in the machining liquid; and

(f) means for hydrodynamically unloading the completed product from the work holding means by utilizing the machining liquid contained in the machining chamber.

2. The machine tool of claim **1** further comprising chip recovery means for recovering from the machining liquid the chips and other solids that are created by machining.

3. The machine tool of claim **1** further comprising:

(a) a second liquid tight enclosure disposed adjacent the first recited enclosure, the second enclosure defining a rinsing chamber;

(b) hatch means disposed between the machining chamber and the rinsing chamber for the transfer of the completed product from the former to the latter; and

(c) a hydraulic circuit for recirculating a rinsing liquid through the rinsing chamber and hence for rinsing the product.

4. The machine tool of claim 1 further comprising temperature control means for controlling the temperature of the machining liquid contained in the machining chamber.

5. A machine tool for machining work with a cutting tool in a submerged state, comprising:

(a) a liquid tight enclosure for containing a machining liquid, the enclosure defining a machining chamber in which work is to be machined;

(b) tool holding means for holding a desired cutting tool in the machining chamber;

(c) work holding means for holding work in the machining chamber;

(d) means for creating relative cutting action between the cutting tool being held by the tool holding means and the work being held by the work holding means in the machining chamber, so that the work is machined into a desired product while being submerged in the machining liquid; and

(e) a hydraulic circuit utilizing the machining liquid contained in the machining chamber for hydrodynamically loading the work on the work holding means and unloading the completed product from the work holding means.

6. The machine tool of claim 5 further comprising a second hydraulic circuit for withdrawing the machining liquid from the machining chamber for the recovery from the machining liquid of the chips and other solids that are created by machining, and for subsequently returning the machining liquid to the machining chamber.

7. The machine tool of claim 5 further comprising:

(a) a second liquid tight enclosure disposed adjacent the first recited enclosure, the second enclosure defining a rinsing chamber;

(b) hatch means disposed between the machining chamber and the rinsing chamber for the transfer of the completed product from the former to the latter after having been unloaded from the work holding means; and

(c) a second hydraulic circuit for recirculating a rinsing liquid through the rinsing chamber and hence for rinsing the product contained therein.

8. The machine tool of claim 5 further comprising temperature control means for controlling the temperature of the liquid contained in the machining chamber.

9. A machine tool for machining work with a cutting tool in a submerged state, comprising:

(a) a liquid tight enclosure for containing a machining liquid, the enclosure defining a machining chamber in which work is to be machined;

(b) tool holding means for holding a desired cutting tool in the machining chamber;

(c) a drive spindle having a hollow extending therethrough and communicating with the machining chamber;

(d) a work holder mounted to one end of the drive spindle and disposed in the machining chamber for holding work therein;

(e) drive means for imparting rotation to the drive spindle and hence to the work being held by the work holder on the drive spindle;

(f) feed means for feeding the cutting tool on the tool holding means against the revolving work, so that the work is machined into a desired product while being submerged in the machining liquid; and

(g) pump means for drawing the machining liquid from the machining chamber into the hollow in the drive spindle in order to load the work on the work holder on the drive spindle, and for forcing the machining liquid into the machining chamber through the hollow in the drive spindle in order to unload the completed product from the work holder.

10. The machine tool of claim 9 further comprising a work chute having an entrance end disposed outside the machining chamber and an exit end disposed adjacent the work holder, the work being introduced into the machining chamber through the work chute before being loaded on the work holder by the action of the pump means.

11. The machine tool of claim 10 wherein the completed product is returned to the exit end of the work chute on being unloaded from the work holder, and wherein the machine tool further comprises:

(a) a second liquid tight enclosure defining a rinsing chamber and disposed under the first recited enclosure, the exit end of the work chute being held against the second enclosure;

(b) hatch means between the exit end of the work chute and the rinsing chamber for the transfer of the completed product from the former to the latter; and

(c) second pump means for recirculating a rinsing liquid through the rinsing chamber and hence for rinsing the product contained therein.

12. The machine tool of claim 9 further comprising a chip recovery vessel in communication with the machining chamber for withdrawing the machining liquid from the machining chamber in order to recover from the machining liquid the chips and other solids that are created by machining.

13. The machine tool of claim 9 wherein the drive spindle is rotatably mounted within a headstock, and wherein the machine tool further comprises an impeller mounted on the drive spindle for joint rotation therewith, the impeller being effective to draw atmospheric air into the head stock both for preventing the leakage of the machining liquid from the machining chamber and for cooling the drive spindle.

14. The machine tool of claim 9 further comprising a headstock, and a hydrostatic bearing for rotatably supporting the drive spindle on the headstock.

15. A machine tool for machining work with a cutting tool in a submerged state, comprising:

(a) a liquid tight enclosure for containing a machining liquid, the enclosure defining a machining chamber in which work is to be machined;

(b) tool holding means for holding a desired cutting tool in the machining chamber;

(c) a drive spindle having a hollow extending therethrough and communicating with the machining chamber;

(d) a work holder mounted to one end of the drive spindle and disposed in the machining chamber for holding work therein;

(e) drive means for imparting rotation to the drive spindle and hence to the work being held by the work holder on the drive spindle;

(f) feed means for feeding the cutting tool on the tool holding means against the revolving work, so that

the work is machined into a desired product while being submerged in the machining liquid; and

(g) a first hydraulic circuit for recirculating the machining liquid out of and back into the machining chamber through the hollow in the drive spindle;

(h) a reversible pump included in the first hydraulic circuit for drawing the machining liquid from the machining chamber into the hollow in the drive spindle in order to load the work on the work holder on the drive spindle, and for forcing the machining liquid into the machining chamber through the hollow in the drive spindle in order to unload the completed product from the work holder, the hollow in the drive spindle being discommunicated from the machining chamber when the work is held by the work holder; and

(i) a second hydraulic circuit including a chip recovery vessel for recovering from the machining liquid the chips and other solids that are created by machining, the chip recovery vessel being in communication with the machining chamber and with the first hydraulic circuit, the reversible pump being effective, when the hollow in the drive spindle is discommunicated from the machining chamber by the work on the work holder, to cause the flow of the machining liquid from the machining chamber into the chip recovery vessel and thence back into the machining chamber via the first hydraulic circuit.

16. The machine tool of claim **15** wherein the chip recovery vessel is removable from the rest of the machine tool, and wherein the machine tool further comprises valve means for discommunicating the chip recovery vessel from the machining chamber and from the first hydraulic circuit.

17. The machine tool of claim **15** wherein the second hydraulic circuit further comprises a filter disposed between the chip recovery vessel and the machining chamber for filtering the machining liquid before being returned to the machining chamber.

* * * * *

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United States Patent [19]

Miyano

[11] Patent Number: 5,291,769

[45] Date of Patent: Mar. 8, 1994

[54] APPARATUS FOR FORMING END PORTION OF PIPE

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[73] Assignee: Kabushiki Kaisha Milano, Mitaka, Japan

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[22] Filed: May 13, 1992

[30] Foreign Application Priority Data

May 16, 1991 [JP] Japan 3-141080

[51] Int. Cl.[5] B21D 41/04

[52] U.S. Cl. 72/121

[58] Field of Search 72/121, 110, 107, 104

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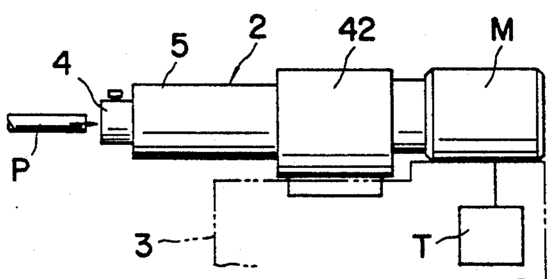
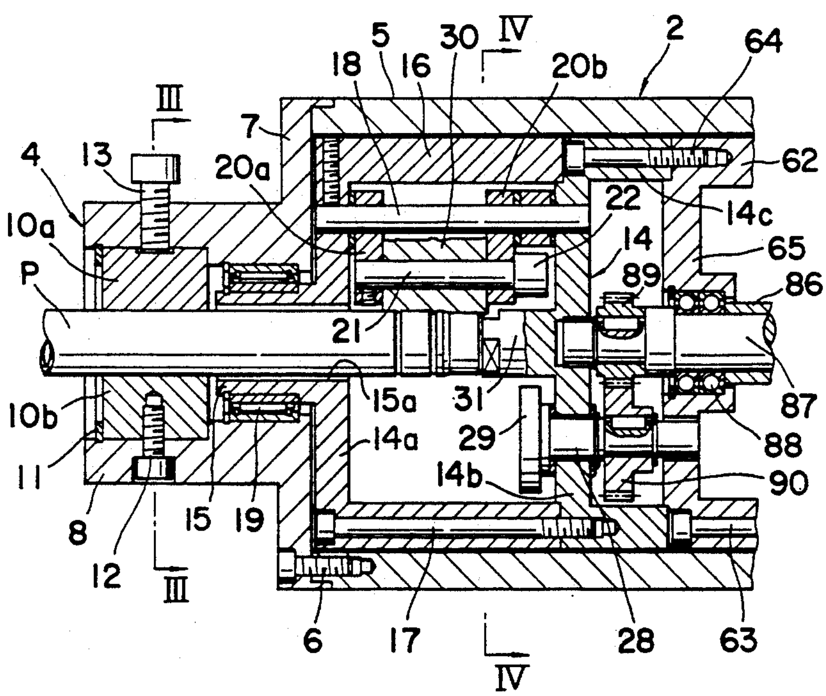
Primary Examiner—Lowell A. Larson
Attorney, Agent, or Firm—Ladas & Parry

[57] ABSTRACT

A plurality of profile rolls which are revolving are radially inwardly pressed against the peripheral surface of an end portion of a pipe to be formed so that a suitable profile is plastically formed on the end portion of the pipe. Each of the profile rolls is rotatably carried by a shaft at the distal end of a swing assembly whose proximal end is pivotably mounted to a pivot shaft on a rotary assembly which is rotatable. A cam follower on the distal end shaft of each swing assembly is forced by a cam laterally so that the rotary assemblies are rotated, resulting in radially inward displacement of the profile roll. Thus, the apparatus is compact in size, easily operable at a working site and reliable in operation.

12 Claims, 5 Drawing Sheets





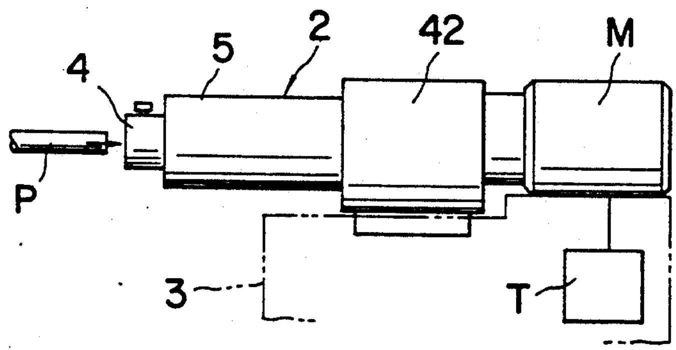

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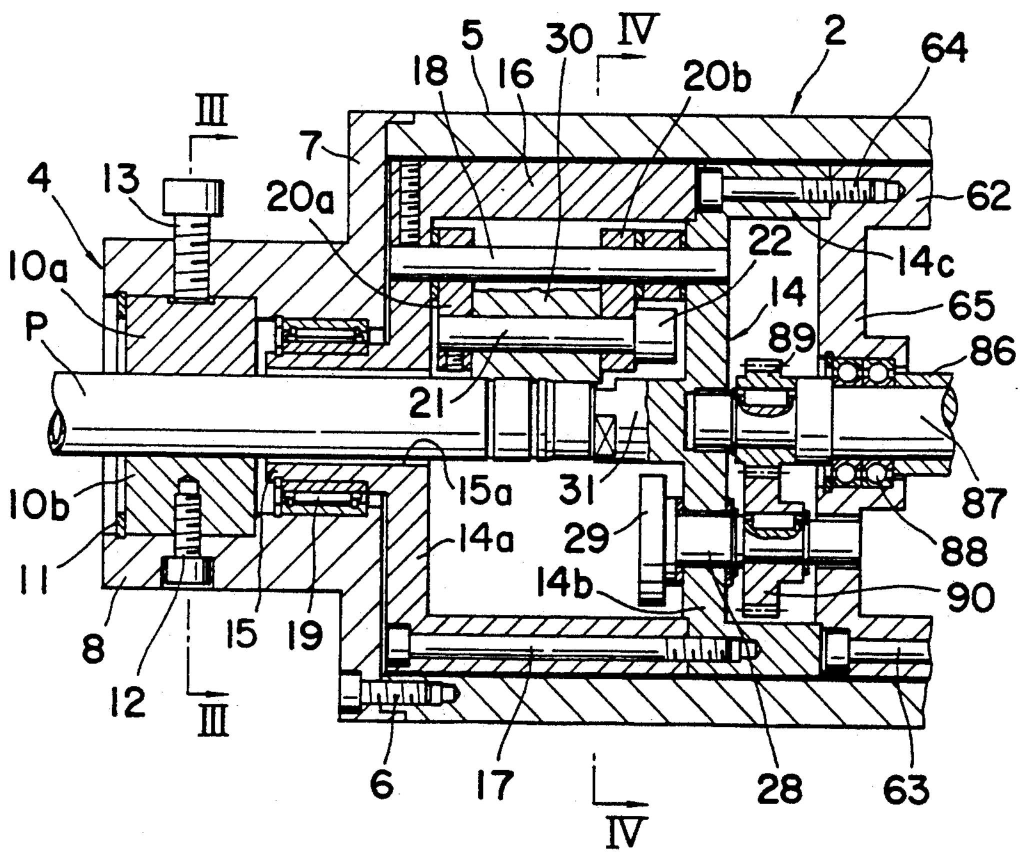
FIG. 1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14c
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87
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FIG. 2

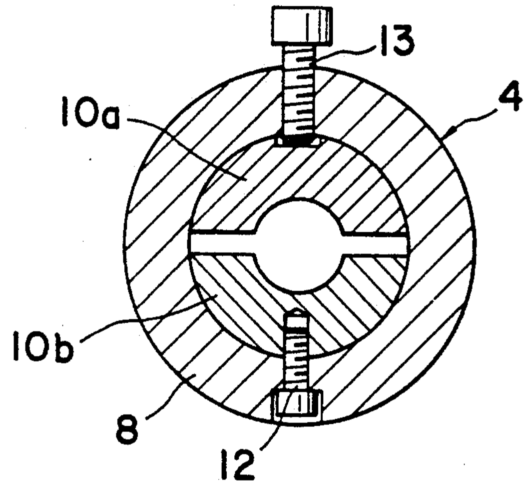

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FIG. 3

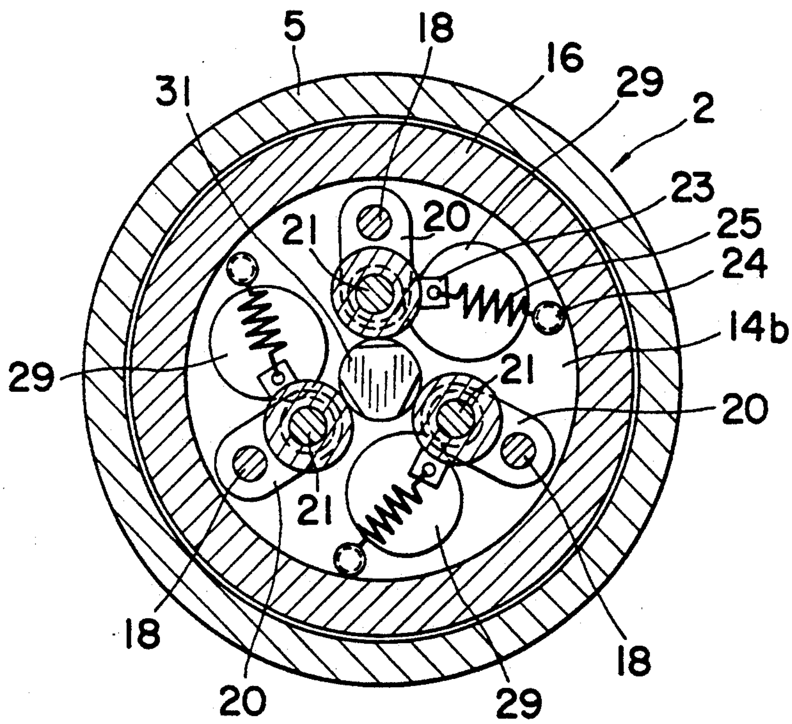

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FIG. 4

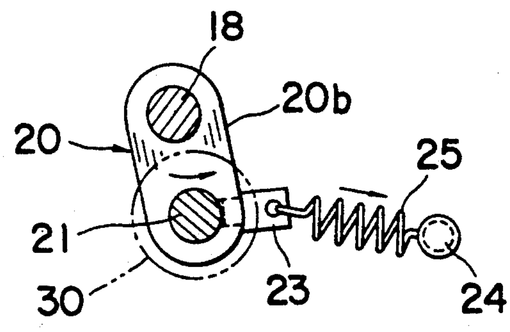


FIG. 5

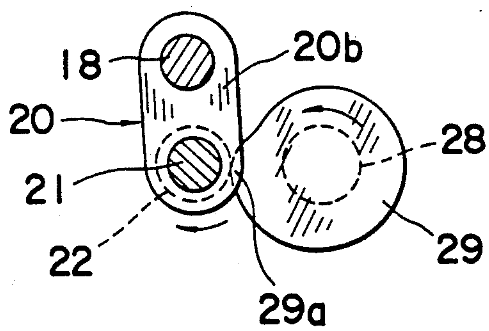


FIG. 6

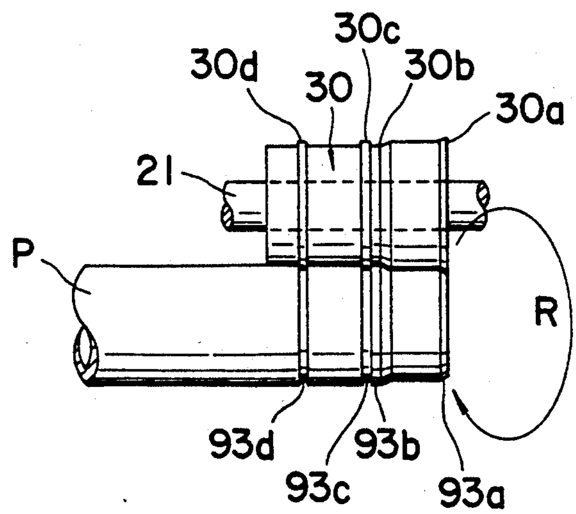
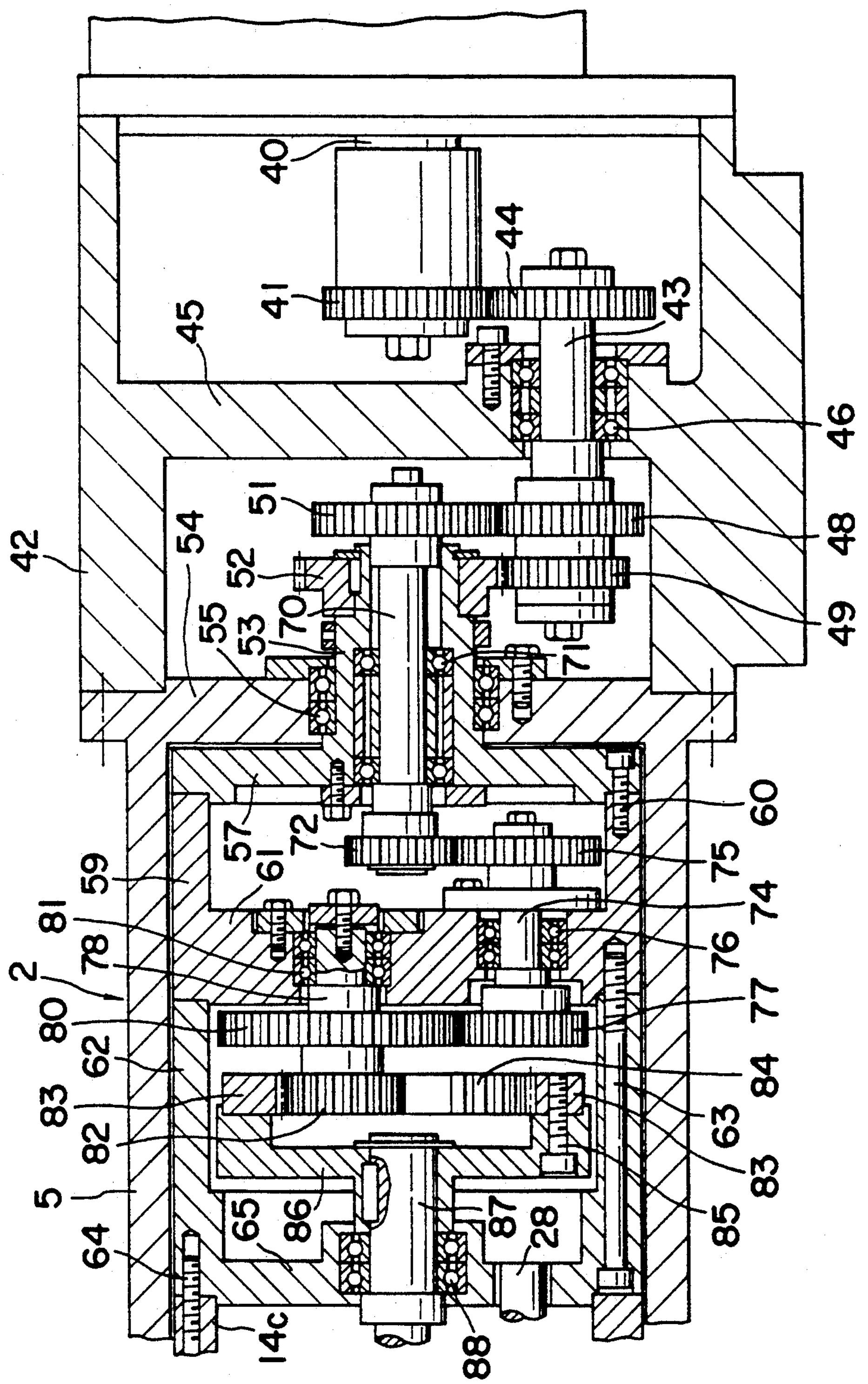


FIG. 7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14c

FIG. 8

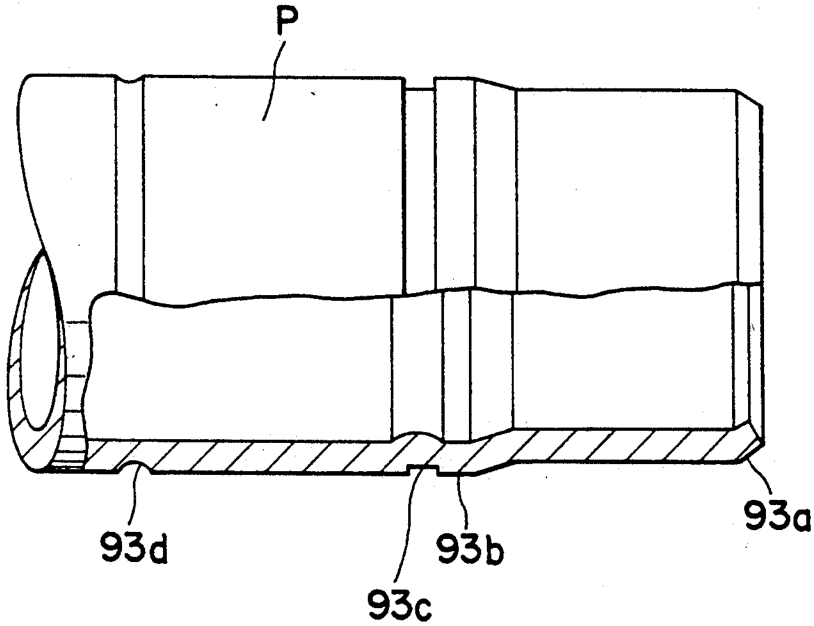

FIG. 9

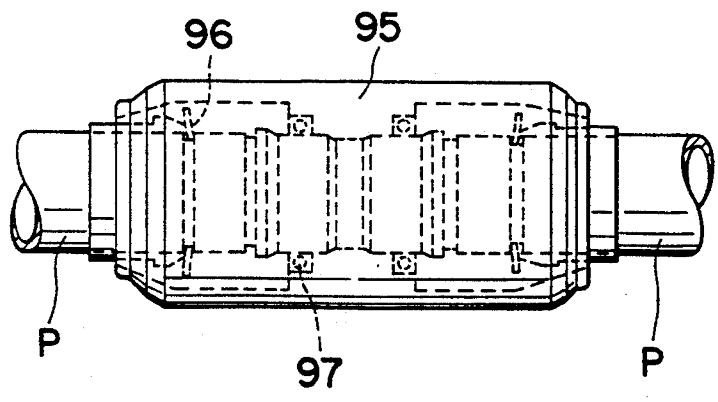

FIG. 10

APPARATUS FOR FORMING END PORTION OF PIPE

BACKGROUND OF THE INVENTION

The present invention relates to an apparatus for forming an end portion of a pipe and, more particularly, to an apparatus for carrying out, at a working site, plastic formation of an end portion of a refrigerant pipe of a refrigerating machine in a simple manner and in such a way that the end portion of the pipe will assume a predetermined profile suitable for connecting two pipe ends through a pipe coupling.

It has been known that plastic formation is carried out at one or both ends of a refrigerant pipe at a working site so that one or both ends of the pipe have a suitably profiled sectional shape in order to facilitate the connection of two pipes through a pipe coupling by merely inserting the formed ends of the pipes into the pipe coupling with a single action. A known pipe-end forming apparatus generally comprises a pipe holding device for rotatably holding a pipe to be formed, a plurality of profile rolls arranged around the peripheral surface of the tip end portion of the pipe held by the pipe holding device so as to press against the pipe end portion during the rotation thereof, and hydraulic cylinders for thrusting the profile rolls radially inwardly against the pipe.

In the known apparatus of the type described above, the profile rolls are radially inwardly pressed by the hydraulic cylinders against the outer peripheral surface of the end portion of the pipe which is caused to rotate whereby a profile complementary to the profile of the profile rolls is formed on the pipe end portion by plastic deformation.

In the case of the known apparatus of the type described above, the forces produced by the hydraulic cylinders are exerted radially to urge the profile rolls to press against the end portion of a pipe, and therefore the hydraulic cylinders must be extended radially outwardly. As a result, the forming apparatus must necessarily be large in bulk. Furthermore, since a pipe to be formed normally having a relatively large length must be rotated so that the pipe holding device is necessarily complex in construction and large in size. Such forming apparatus large in size is very inconvenient for transportation to a working site at which pipes are processed.

SUMMARY OF THE INVENTION

The present invention has been made to solve the above and other problems encountered in the known apparatus for forming a pipe end portion and has for its object to provide an apparatus for forming an end portion of a pipe, which is compact in size so that the transportation of the apparatus is facilitated and which is simple to operate because it is not needed to rotate the pipe to be formed.

In order to attain the above described object, the apparatus for forming an end portion of a pipe comprises: pipe holding means for securely holding an end portion of a pipe to be formed; rotary means provided adjacent to said pipe holding means so as to be rotatable coaxially with the end portion of the pipe held by the pipe holding means; drive means for rotating the rotary means; a plurality of shafts securely held by the rotary means so as to extend parallel with the pipe held by the pipe holding means; a plurality of swing means having proximal ends pivoted to said shafts, respectively, and having distal ends directed radially inward so as to be in

opposing relationship with the end portion of the pipe to be formed; a plurality of profile rolls carried by the distal ends of the swing means, respectively; biasing means for imparting forces to the swing means so that the swing means will be caused to rotate in such directions that the profile rolls are moved away from the end portion of the pipe; and lateral force application means supported by the rotary means adjacent to a lateral side of each swing means for imparting a force to each swing means in a lateral direction across the swing means against the force of the biasing means.

When a pipe to be formed is clamped by the pipe holding means and then drive means is energized to rotate the rotary means and to energize the lateral force application means, the swing means which are supported by the shafts, respectively, revolve around the end portion of the pipe and swing slowly by the action of lateral force application means. Each of the profile rolls which are supported by the shafts at the distal ends, respectively, of the swing means gradually approaches the pipe to press against the outer peripheral surface thereof so that a profile complementary to that of the profile rolls is plastically formed around the surface of the end portion of the pipe. After the above described forming process has been completed, the lateral force application means are deenergized and the profile rolls and the swing means which hold the profile rolls, respectively, move away from the formed pipe under the force of the biasing means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevational view illustrating an apparatus for forming an end portion of a pipe in accordance with the present invention;

FIG. **2** is a vertical section, on an enlarged scale, illustrating the lefthand end portion of the apparatus shown in FIG. **1**;

FIG. **3** is a sectional view taken along the line III—III of FIG. **2**;

FIG. **4** is a sectional view taken along the line IV—IV of FIG. **2**;

FIG. **5** is a view for explaining the relationship between a swing assembly and biasing means;

FIG. **6** is a view explanatory of the relationship between a rotary assembly and a cam;

FIG. **7** is an elevation showing the relationship between a profile roll and a pipe to be formed;

FIG. **8** is a sectional view illustrating an intermediate portion of the apparatus shown in FIG. **1**;

FIG. **9** is an elevation, on an enlarged scale, of a pipe formed; and

FIG. **10** is an elevation illustrating a coupling joining two pipes formed by the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the accompanying drawings, an embodiment of the present invention will be described.

FIG. **1** illustrates the whole construction of a pipe end portion forming apparatus in accordance with the present invention. In FIG. **1**, a main body **2** of the pipe end portion forming apparatus is mounted horizontally on a supporting stand **3**. A driving device M such as an electric motor is mounted at one end of the main body **2** while at the other end there is provided a pipe clamping device **4** for securely holding an end portion of a

pipe P to be formed. When the pipe is to be formed, it is inserted into the clamping device **4**.

FIG. **2** shows in vertical section a lefthand side portion of the main body **2**. The main body **2** has a cylindrical casing **5** on the left end as viewed in FIG. **2**. The pipe clamping device **4** is secured to the casing **5** by means of bolts **6**. The pipe clamping device **4** comprises a mounting plate **7**, and a cylinder **8** formed integral with the mounting plate **7**. Upper and lower chuck halves **10***a* and **10***b* are housed within the cylinder **8** in such a way that they are prevented from slipping out from the lefthand end of the cylinder **8**.

As shown in a cross sectional view taken along the line III—III of FIG. **2**, the chuck halves **10***a* and **10***b* are each in the form of a semicircular arc. The lower chuck half **10***b* is securely attached to the cylinder **8** with bolts **12** while the upper chuck half **10***a* is adapted to move downwardly when a locking bolt **13** threadably passed through the cylinder **8** is screwed downwardly. Therefore, when the end portion of the pipe P to be formed is inserted from the left to the right in FIG. **2** between the chuck halves **10***a* and **10***b* and then the bolt **13** is tightened, the pipe P to be formed is clamped immovably between the upper and lower chuck halves **10***a* and **10***b*.

As shown in FIG. **2**, a rotary assembly **14** is disposed within the casing **5** adjacent to the pipe clamping device **4**. The rotary assembly **14** has a pair of parallel rotary disks **14***a* and **14***b*. In this embodiment, the rotary disks **14***a* and **14***b* are fixedly secured to each other by means of bolts **17** which are passed through a cylindrical portion **16** made integral with one rotary disk **14***a*. A hollow stub shaft **15** integral with the rotary disk **14***a* is extended axially from the center thereof and is rotatably supported within the cylinder **8** through a bearing **19**. The stub shaft **15** has a hole **15***a* through which the end portion of the pipe P is passed.

A plurality of pivot shafts **18** extend in parallel with the pipe P to be formed and are fixed at both ends thereof to the rotary disks **14***a* and **14***b*. As is clearly seen from FIG. **4**, which is a sectional view taken along the line IV—IV in FIG. **2**, the ends of the pivot shafts **18** are equiangularly secured to the disk plates **14***a* and **14***b*, respectively, and the number of the shafts **18** are three, for example. A swing assembly **20** is swingably mounted at its proximal end to each pivot shaft **18**. The swing assembly **20** comprises a pair of swing arms **20***a* and **20***b* (FIG. **2**) which are spaced apart axially from each other by a suitable distance. These swing arms **20***a* and **20***b* are radially inwardly extended from each pivot shaft **18** toward the outer peripheral surface of the pipe P to be formed and have a common mounting shaft **21** securely attached to the distal ends thereof, respectively. A cam follower **22** is securely attached on the end of the shaft **21** on the side of the rotary disk **14***b*.

As shown in FIGS. **4** and **5**, a tension spring **25** is loaded between a spring retaining bracket **23** on one side of the distal end of the swing arm **20***b* and a pin **24** fixed on the rotary disk **14***b*, so that the swing assembly **20** is biased in the counterclockwise direction by the tension spring **25**. The tension spring **25** constitutes biasing means.

As shown in FIG. **2**, rotary cam shafts **28** are passed through and supported by the rotary disk **14***b* and cams **29** are securely fixed to the cam shafts **28**, respectively. Each of the cams **29** is disposed adjacent to each corresponding swing assembly **20**. As shown in FIG. **6**, the cam **29** has a raised lobe portion **29***a* on the peripheral surface thereof. Each cam **29** coacts with each corresponding cam follower **22**. When the lobe portion **29***a* engages the cam follower **22** as the cam shaft **28** is rotated, the swing assembly **20** is caused to rotate about the shaft **18** in the clockwise direction against the force of the tension spring **25** as viewed in FIG. **6**.

As indicated in FIG. **2**, a profile roll **30** is rotatably carried by the mounting shaft **21** at the distal end of each swing assembly **20** so that the roll **30** can be rotatable between the swing arms **20***a* and **20***b*. As shown in FIG. **7**, the peripheral surface of the profile roll **30** is formed with a suitable profile. In this embodiment, the profile is shown to have a projection **30***a*, a recess **30***b* and projections **30***c* and **30***d*.

The profile roll **30** is spaced apart from the peripheral surface of the pipe P to be formed in the state of FIG. **5**, while in the state as shown in FIG. **6** in which the cam lobe portion **29***a* acts on the cam follower **22**, the profile roll **30** is pressed against the peripheral surface of the pipe P to be worked.

As shown in FIG. **2**, a pipe abutment portion **31** projects toward the pipe P to be formed from the center of the rotary disk **14***b*. When the pipe P is inserted into the pipe clamping device **4**, the end of the pipe P will abut against the abutment portion **31** to be axially placed in position.

When the rotary assembly **14** including the rotary disks **14***a* and **14***b* are caused to rotate by a rotation mechanism to be described hereinafter, the swing arms **20***a* and **20***b*, cam followers **22**, cams **29** and profile rolls **30** which are all supported by the rotary assembly **14** will be caused to revolve around the pipe P to be formed. While revolving, the cams **29** will be rotated through the respective cam shafts **28** by the rotation mechanism and will act on the cam followers **22**. The above-mentioned mode of operation will be described in more detail hereinafter.

The rotation mechanism which causes the rotation of the rotary assembly **14** and the cam shafts **28** concurrently will be described with reference to FIG. **8**, which illustrates a central portion of FIG. **1** on an enlarged scale as well as a mechanism connected to the righthand side of the mechanism shown in FIG. **2**.

In FIG. **8**, the output shaft of the motor M (not shown in this figure) is shown at **40** on the righthand side of FIG. **8**. The output shaft **40** has a gear **41** in mesh with a gear **44** at one end of a first intermediate shaft **43** which is rotatably supported through a bearing **46** by a partition wall **45** within a casing **42** that is securely joined to the casing **5**. The intermediate shaft **43** carries two gears **48** and **49** at the other end thereof. The gear **48** is in mesh with a gear **51** while the other gear **49**, a gear **52**.

The gear **52** is securely mounted on a hollow shaft **53** which is rotatably supported through a bearing **55** by a partition wall **54** integral with the casing **5**. The hollow shaft **53** has a circular flange **57** integral therewith which is securely attached to a first cylindrical member **59** by means of bolts **60**. The flange **57** is made integral with a partition wall **61**. Furthermore, the first cylindrical member **59** is securely attached to a second cylindrical member **62** with bolts **63**, and the member **62** is securely attached to an annular flange **14***c* of the rotary assembly **14** with bolts **64** as also shown in FIG. **2**. The second cylindrical member **62** has a partition wall **65** integral therewith.

When the motor M is energized to operate the above-described rotation mechanism, the rotary assembly **14** is caused to rotate through the output shaft **40** of the

motor M, the gears **41** and **44**, the first intermediate shaft **43**, the gears **49** and **52**, the hollow shaft **53**, the first and second cylindrical members **59** and **62**.

The gear **51** is securely carried by one end of a second intermediate shaft **70** which is rotatably supported through a bearing **71** within the hollow shaft **53**. The other end of the second intermediate shaft **70** carries a gear **72** which is engaged with a gear **75** carried by one end of a third intermediate shaft **74**. The shaft **74** is supported through a bearing **76** by the partition wall **61** and carries a gear **77** on the opposite side thereof. The gear **77** is in mesh with a gear **80** fixed to a support shaft **78**, which is rotatably supported by the partition wall **61** via a bearing **81**.

A further gear **82** is securely mounted on the support shaft **78** in coaxial relationship with the gear **80**. The gear **82** is engaged with an internal ring gear **83** which is securely fixed to an annular member **86** with bolts **85**. The annular member **86** is securely mounted on a fourth intermediate shaft **87** which is supported through a bearing **88** by the partition wall **65**.

As shown in FIG. **2**, the lefthand end of the intermediate shaft **87** is supported in a recess of the rotary disk **14***b* and a gear **89** is securely mounted on the intermediate shaft **87** at a position near the end thereof. The gear **89** is in mesh with three gears **90** securely carried by the three cam shafts **28**, respectively.

When the motor M with the above described rotation mechanism is energized, the three cams **29** are rotated in synchronism with each other through the output shaft **40**, gear **41**, first intermediate shaft **43**, gears **48** and **51**, second intermediate shaft **70**, gears **72** and **75**, third intermediate shaft **74**, gears **77** and **80**, support shaft **78**, gear **82**, internal ring gear, annular member **86**, fourth intermediate gears **87**, gear **89** and three cam shafts **28**. The rotation of these cams **29** is carried out while revolving in response to the rotation of the rotary assembly **14**.

As shown in FIG. **1**, the motor M is controlled by a timer T. After a predetermined time interval set by the timer T, the motor M is automatically deenergized.

The mode of operation of the pipe end portion forming apparatus with the above stated construction will now be described.

At the site where a pipe is to be connected to a pipe coupling, a pipe P to be formed is inserted into the pipe end portion forming apparatus in the direction indicated by the arrow in FIG. **1** so that the leading end of the pipe P is brought into contact with the abutment portion **31** and the pipe is securely positioned in the axial direction. Thereafter, the locking bolt **13** is tightened so that the pipe P is securely clamped and held in position by the chuck halves **10***a* and **10***b*.

Thereafter, the motor M is connected to the power source and is energized. Then, the rotary assembly **14** and all the cam shafts **28** are rotated so that all the cams **29** are also caused to rotate. As a result, the peripheral surface gradually increasing in diameter of each cam **29** starts to thrust the corresponding cam follower **22**. Therefore, as best shown in FIG. **4**, all the swing assemblies **20** start to rotate gradually about the respective shafts **18** against the force of the biasing springs **25** in the clockwise direction. Because of the rotation of the swing assemblies **20** described above, the profile rolls **30** are caused to gradually approach the peripheral surface of the pipe P to be formed and push them radially inwardly. While pushing the pipe, all the profile rolls **30** revolve around the pipe P because of the rotation of the rotary assemblies **14** so that profile rolls **30** are forcibly pressed against the peripheral surface of the pipe P while revolving in the direction indicated by the arrow R. Until the cam lobe portions **29***a* finally engage the cam followers **22**, the cross section of the pipe P is caused to assume the section shown in FIG. **7** having the profile complementary to that of the profile rollers **30** by plastic deformation. More specifically, as shown FIGS. **7** and **9**, a tapered surface **93***a*, an annular protrusion **93***b* and grooves **93***c* and **93***d* are formed in accordance with the projection **30***a*, recess **30***b* and projections **30***c* and **30***d* of the profile roll **30**, respectively. It is to be noted that the profile rolls **30** may have any suitable profile pattern.

The motor M is deenergized after lapse of a time interval set by the time T. When the time has elapsed, the cam lobes **29***a* have moved off the cam followers **22** and the lowermost peripheral surface portion of each cam **29** is in contact with the corresponding cam follower **22**. Therefore, the swing assemblies **20** have returned to their initial position indicated in FIG. **5** under the force of the bias springs **25** and the profile rolls **30** have moved away from the peripheral surface of the pipe P. When the locking bolt **13** is loosened, the formed pipe P can be withdrawn from the pipe clamping device **4**.

The thus formed end portion of the pipe is inserted into a coupling main body **95** from the right and left sides as shown in FIG. **10**. Because of the formation of the grooves, tapered surfaces and so on over the peripheral surface of the end portion of the pipe P, it can be inserted by one step into, and held tightly by, the coupling main body through elastic engaging members **96** and annular seal members **97**.

According to the present invention, the profile rolls are caused to revolve around and pressed radially inwardly against a pipe to be formed which is securely clamped. Therefore the plastic profile formation over the peripheral surface of the pipe to be formed can be accomplished without the cumbersome work for rotating a pipe to be formed about its longitudinal axis. The side force imparting means, such as cams, gradually press and swing the rotary assembly in order to press the profile rolls against a pipe to be formed. As a result, as compared with the prior art of the type in which hydraulic cylinders are used for radially inward pressing from outside, the mechanism is compact in size or less bulky, light in weight and reliable in operation.

What is claimed is:

1. An apparatus for forming an end portion of a pipe comprising:

stationary pipe holding means for securely and stationarily holding an end portion of a pipe to be formed;

rotary means provided adjacent to said pipe holding means so as to be rotatable coaxially with the end portion of said pipe held by said pipe holding means;

drive means for rotating said rotary means;

a plurality of pivot shafts securely held by said rotary means so as to extend parallel with and be disposed around said pipe held by the pipe holding means;

a plurality of swing arm means having proximal ends pivoted to said pivot shafts, respectively, and having distal ends directed radially inward in opposing relationship with said end portion of said pipe to be formed;

a plurality of profile rolls carried by the distal ends of said swing arm means, respectively;

biasing means for imparting forces to said swing arm means so that said swing arm means will be caused to rotate about said pivot shafts in such directions that said profile rolls are moved away from said end portion of the pipe in a substantially cirucmferential direction of the pipe; and

lateral force application means supported by said rotary means adjacent to a lateral side of each swing arm means for imparting a force to each swing arm means in a lateral direction across the swing arm means against the force of said biasing means in such a manner that the profile roll on each swing arm means will advance substantially circumferentially of said end portion of the pipe to act on the end portion radially inwardly of the same.

2. The apparatus according to claim 1, wherein said pipe holding means has therein chuck means for immovably clamping the end portion of the pipe.

3. The apparatus according to claim 1, wherein said rotary means includes mutually parallel rotary disks spaced apart in the axial direction of the end portion of the pipe, and that one of the rotary axis has an axial hole through which the end portion of the pipe is inserted into the space between the rotary disks, and the other of the rotary disks has an abutment portion for abutting engagement with the inserted end portion of the pipe.

4. The apparatus according to claim 3, wherein said pivot shafts are disposed in angularly spaced relation

about the axis of rotation of the rotary means and are fixedly secured to the rotary disks at both ends thereof.

5. The apparatus according to claim 4, wherein each of said swing arm means comprises swing arms disposed between said rotary disks in an axially spaced relation, and each of said profile rolls is provided between the rotary disks.

6. The apparatus according to claim 5, wherein said profile roll is rotatably mounted on a mounting shaft fixed to distal ends of the swing arms so as to extend parallel to said pivot shafts.

7. The apparatus according to claim 6, wherein said mounting shaft has on one end thereof means to be acted upon by said lateral force application means.

8. The apparatus according to claim 7, wherein said lateral force application means is a rotary cam disposed laterally of the swing arms and said means to be acted upon is a cam follower.

9. The apparatus according to claim 8, wherein said rotary cam is rotatably supported by said other rotary disk.

10. The apparatus according to claim 9, wherein said rotary cam has a peripheral surface of gradually increasing radius with a projecting lobe.

11. The apparatus according to claim 1, wherein said biasing means are springs each having one end anchored to the rotary means and the other end anchored to the swing means.

12. The apparatus according to claim 1, wherein said drive means is operatively connected to said lateral force application means.

* * * * *

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United States Patent [19]

Miyano

[11] **Patent Number: 5,518,545**

[45] **Date of Patent: May 21, 1996**

[54] **APPARATUS FOR CONVEYING DISCRETE PARTS**

[76] Inventor: **Toshiharu T. Miyano**, 50 Dundee La., Barrington Hills, Ill. 60010

[21] Appl. No.: **246,942**

[22] Filed: **May 19, 1994**

[51] **Int. Cl.**[6] **B05C 13/00**

[52] **U.S. Cl.** **118/500**; 118/300; 118/305; 118/320; 118/501; 406/111; 406/113; 406/177; 406/186

[58] **Field of Search** .... 104/138.2, 138.1; 105/241.2, 241.1, 244; 406/109, 110, 111, 112, 113, 83, 84, 176, 180, 177, 154, 186, 194, 191–198, 197, 167, 164; 414/217, 220, 222, 359, 357, 581; 118/300, 500, 319, 501, 320, 66, 322, 305, 314; 269/13, 14, 309, 304, 289 MR

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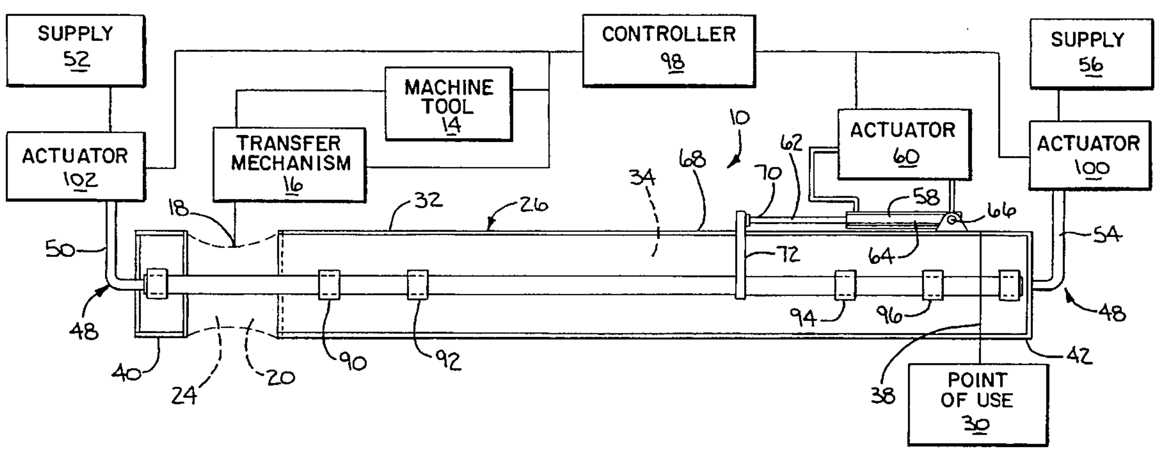
Primary Examiner—Laura Collins

Attorney, Agent, or Firm—Wood, Phillips, VanSanten, Clark & Mortimer

[57] **ABSTRACT**

An apparatus for conveying discrete parts between first and second locations. The conveying apparatus has a receptacle for at least one part. Structure is provided for guiding movement of the part receptacle between the first and second locations. Structure is also provided for conveying the part receptacle a) from the first location to the second location and b) from the second location to the first location.

22 Claims, 6 Drawing Sheets



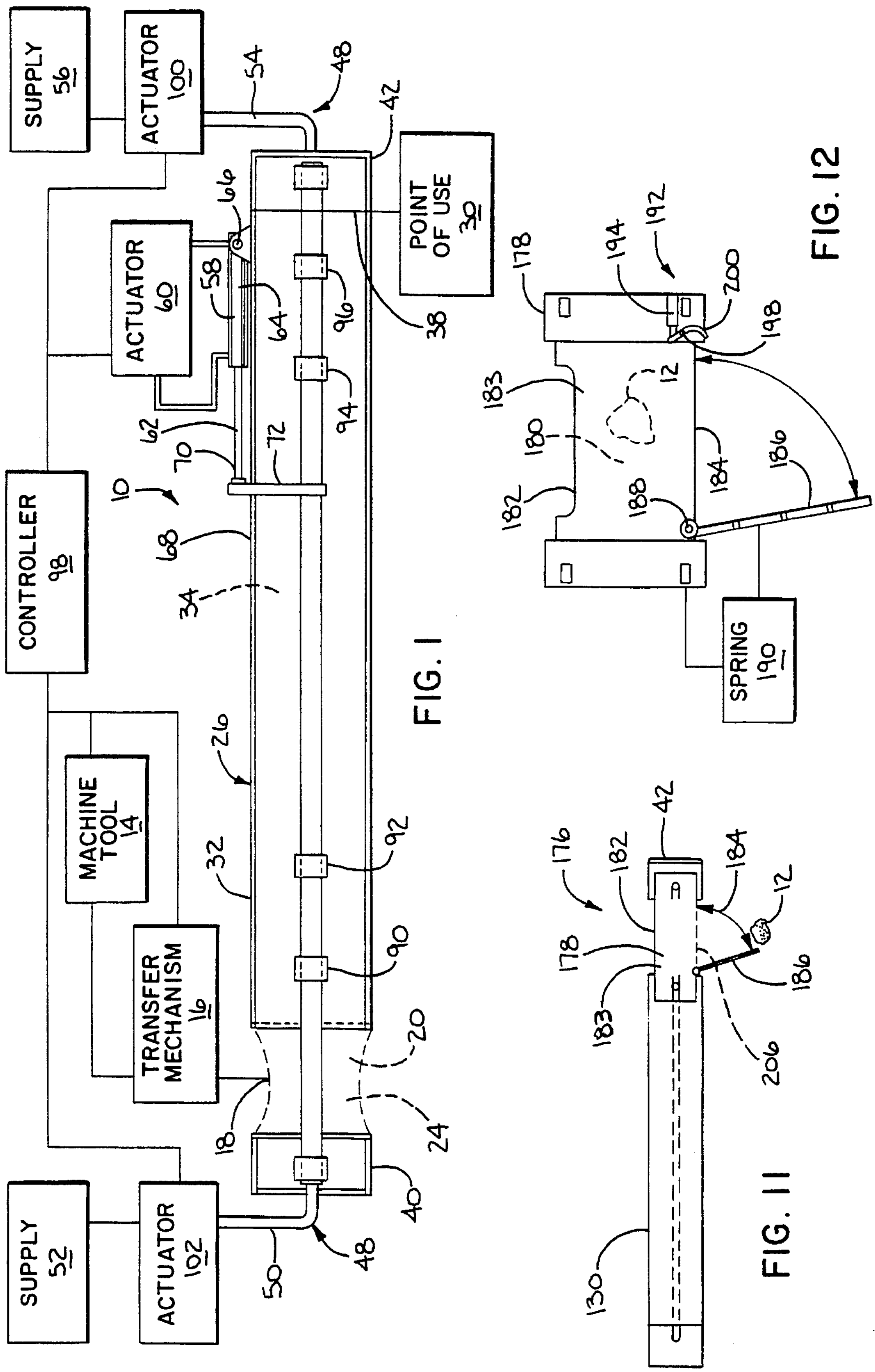


FIG. 1

FIG. 11

FIG. 12

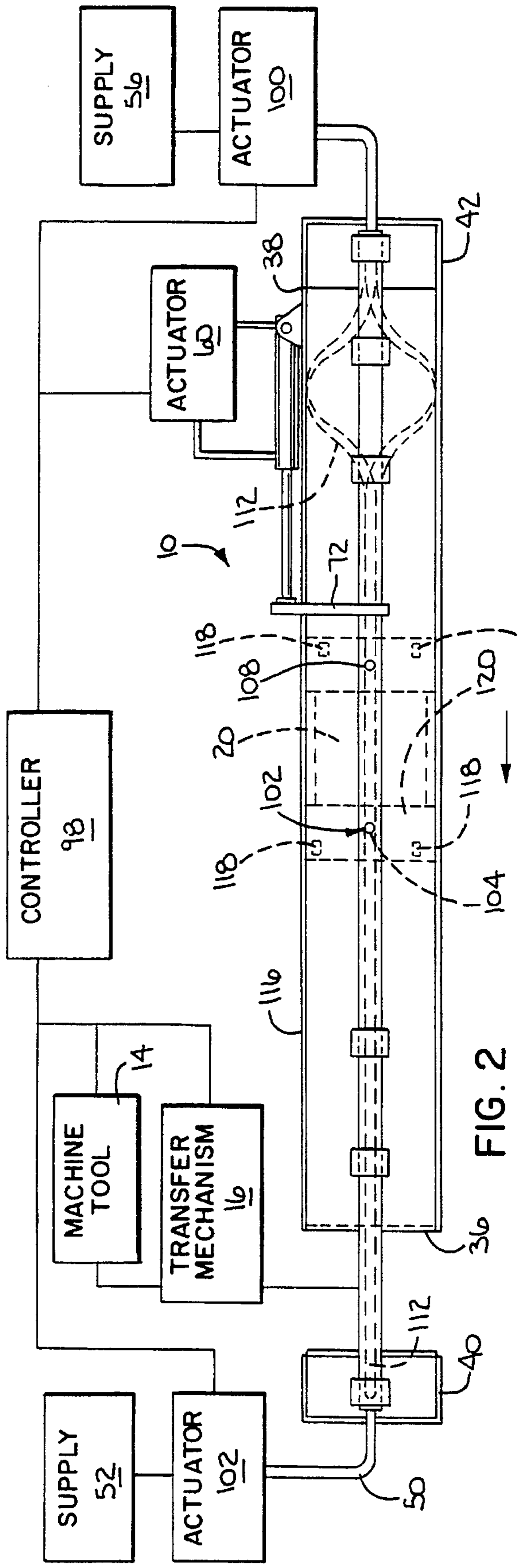

SUPPLY 56
ACTUATOR 100
ACTUATOR 60
CONTROLLER 98
MACHINE TOOL
TRANSFER MECHANISM 16
SUPPLY 52
ACTUATOR 102

FIG. 2

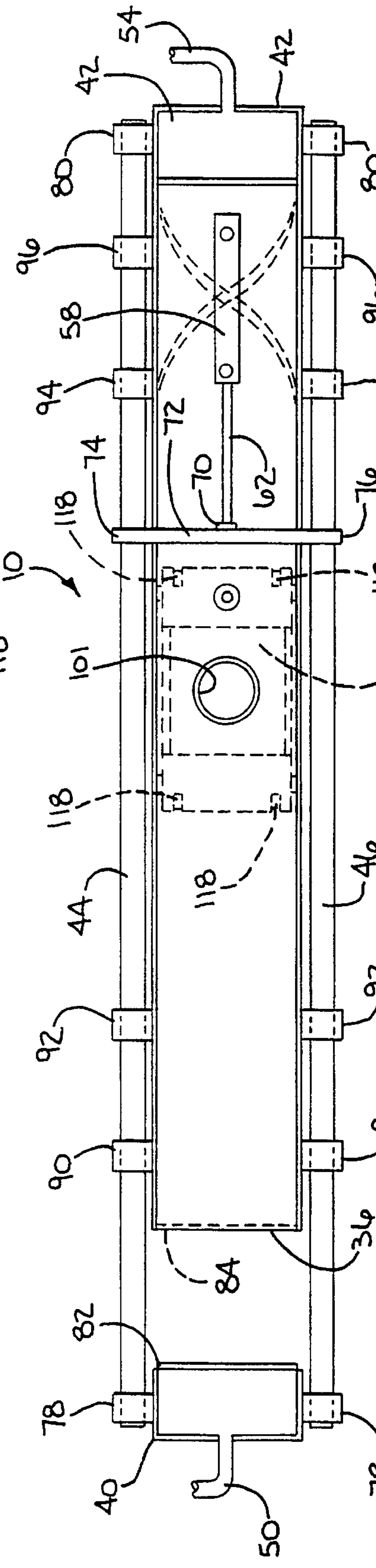


FIG. 3

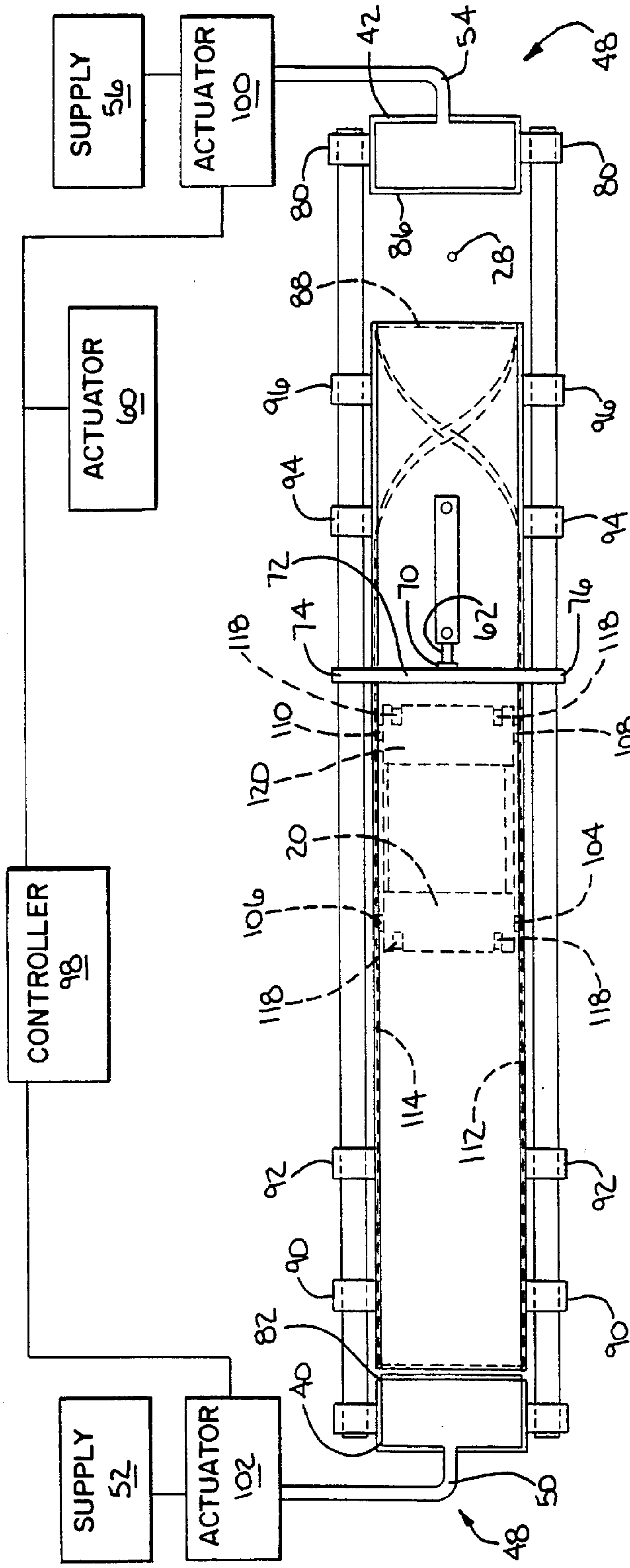

SUPPLY 56
ACTUATOR 100
ACTUATOR 60
CONTROLLER 98
SUPPLY 52
ACTUATOR 102

FIG. 4

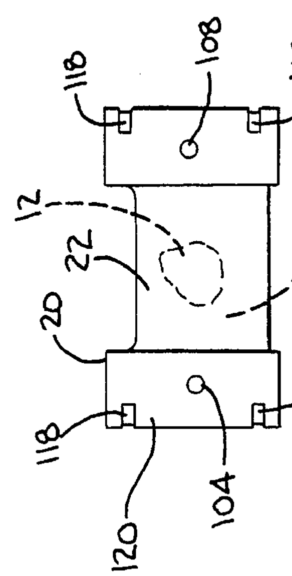


FIG. 5

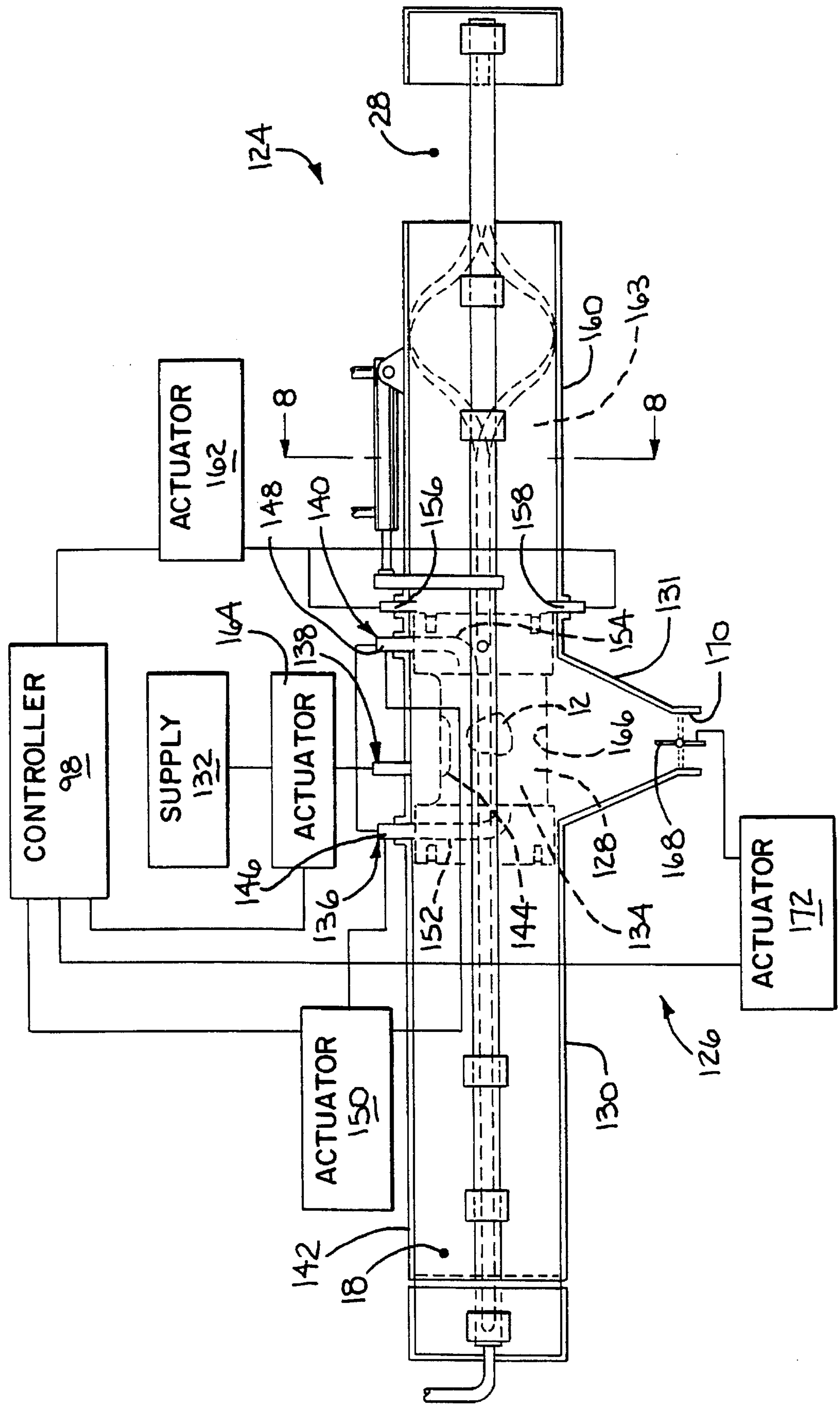

ACTUATOR 162
CONTROLLER 98
SUPPLY 132
ACTUATOR
ACTUATOR 150
ACTUATOR 172

FIG. 6

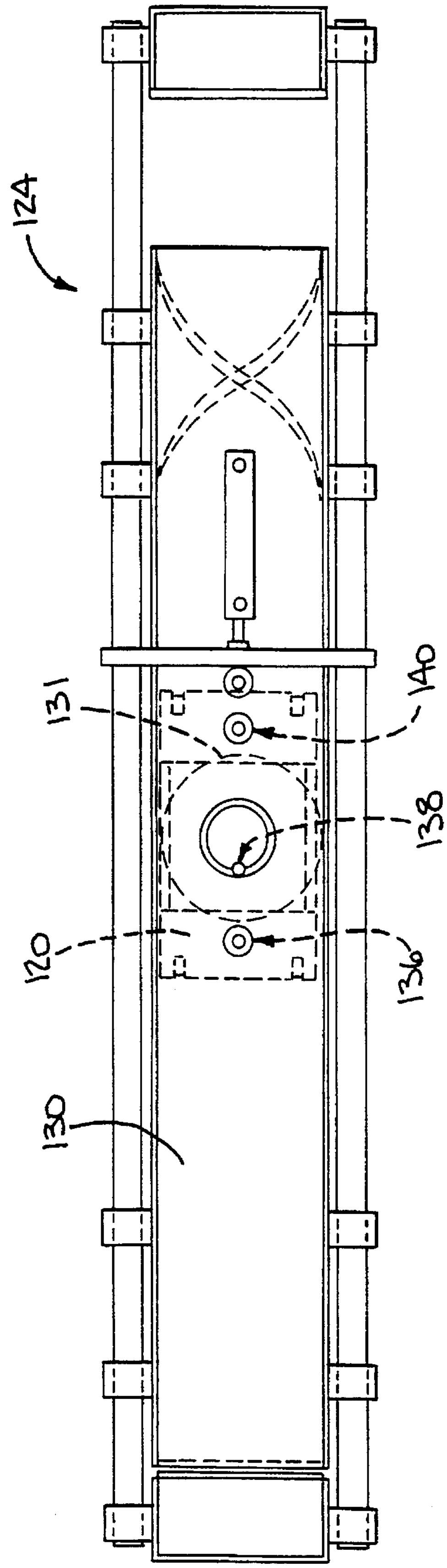


FIG. 7

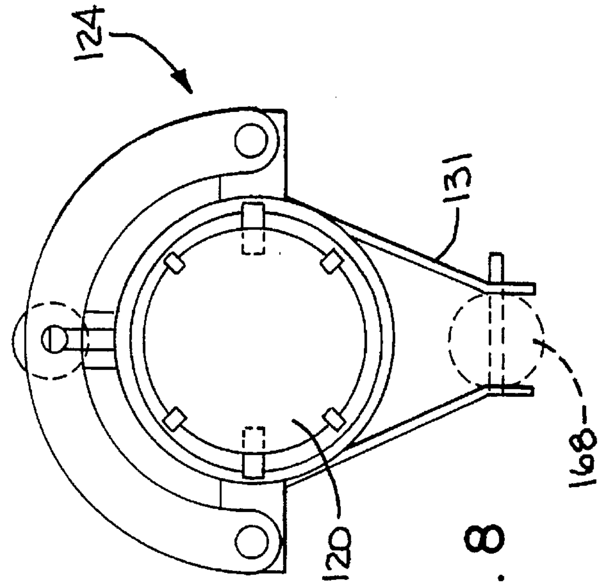


FIG. 8

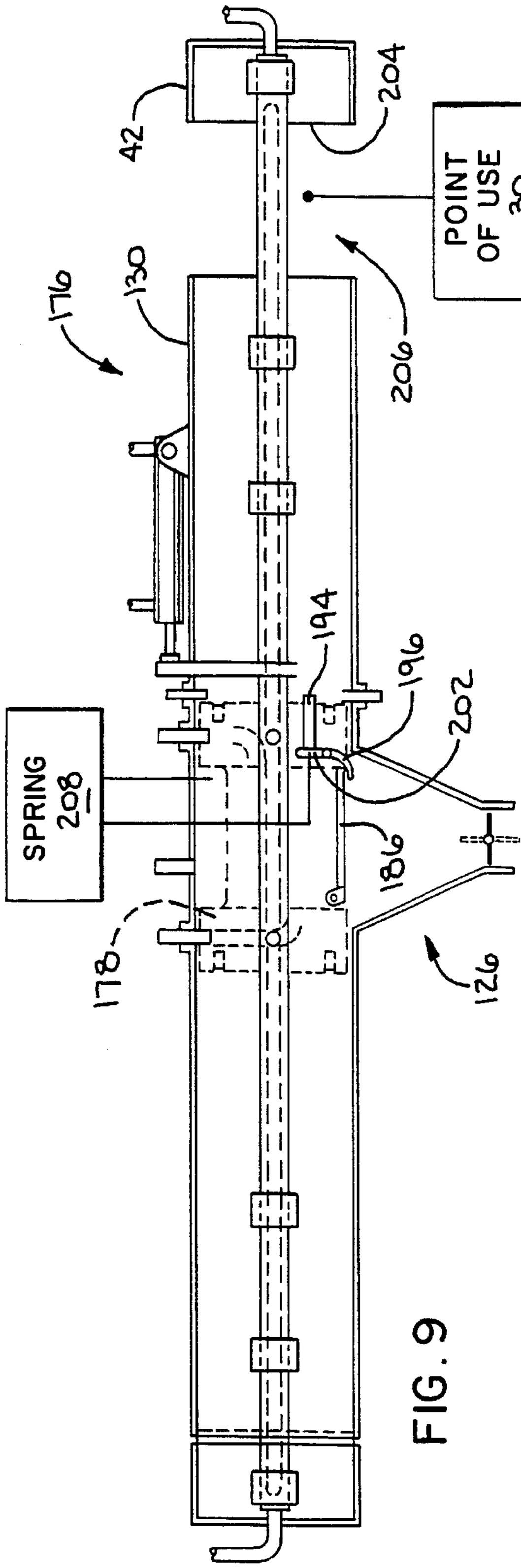

42
204
POINT OF USE 30
176
130
206
194
196
202
SPRING 208
186
178
126

FIG. 9

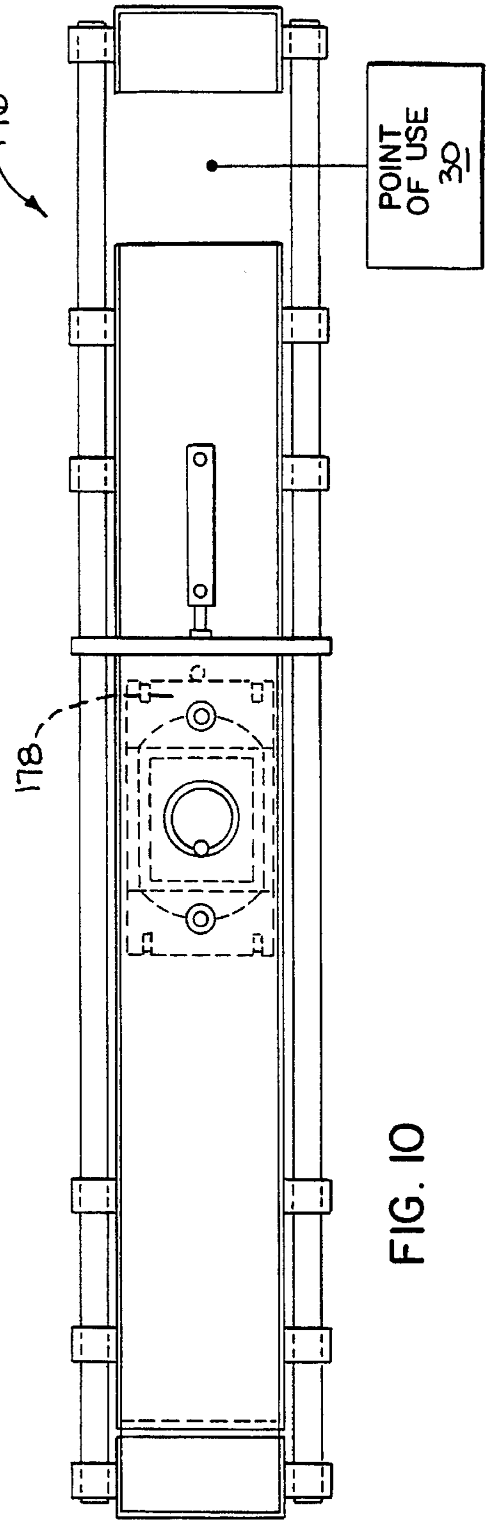

POINT OF USE 30
176
178

FIG. 10

APPARATUS FOR CONVEYING DISCRETE PARTS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an apparatus for moving a part receptacle back and forth between first and second locations wherein parts can be placed in the part receptacle at the first location and removed from the part receptacle at the second location.

2. Background Art

It is known to use automated conveyors to transfer discrete parts between two different locations. In one exemplary system, a part that has been operated upon by a machine tool is conveyed away from the machining location to another machining location, a storage bin, or other appropriate location.

One known conveyor construction employs an endless belt trained around a plurality of rollers. With the belt driven in use, parts can be supported on, and conveyed by, the upwardly facing surface of the conveyor belt.

This conventional conveyor system has a number of drawbacks. First of all, the conveyed parts are fully exposed during conveyance. There is no practical way in these systems to shield the parts as they are conveyed.

Secondly, the parts are normally held on the conveyor belt by friction forces between the parts and upper belt surface. At steep angles, the parts are prone to slipping. This may altogether prevent conveyance or may cause an irregular spacing to develop between successive parts on the upper surface of the conveyor belt.

Specialty conveyors may utilize vacuum, magnets, or the like to cause the parts to adhere to the conveyor belt. However, these systems may become complicated and expensive.

A further problem with conventional conveyors of the type described above is that they are generally one-dimensional. That is, they perform a conveying function but do not lend themselves to facilitating the performance of other steps on the conveyed parts. For example, if the parts are to be washed or otherwise treated with a fluid, these operations must normally be carried out at a location away from the conveyor. Otherwise, the treating fluid adheres to the conveyor belt surface and/or the belt operating structure in such a fashion that the conveyor function may be impaired. The treating material may also spread undesirably to the surrounding work area.

The performance of an operation on the conveying parts is difficult in the case of frictionally held parts. The parts tend to orient randomly on the conveying surface and may not be accurately spaced and oriented to allow automated performance of desired steps on the conveying parts.

SUMMARY OF THE INVENTION

The present invention is specifically directed to overcoming the above enumerated problems in a novel and simple manner.

In one form of the invention, an apparatus is provided for conveying discrete parts between first and second locations. The conveying apparatus has a receptacle for at least one part. Structure is provided for guiding movement of the part receptacle between the first and second locations. Structure is also provided for conveying the part receptacle a) from the

first location to the second location and b) from the second location to the first location.

The part receptacle has structure for releasably accepting a discrete part whereby the part can be placed into the part receptacle at the first location and removed from the part receptacle at the second location.

In one form, the guiding structure is defined by an elongate conduit having an internal space within which the part receptacle is guided between the first and second locations. The elongate conduit has first and second ends with there being structure for selectively closing and opening the first and second ends of the elongate conduit. The structure for conveying the part receptacle may be a pneumatic structure for conveying the part receptacle in the internal space a) from the first location to the second location with the first closing structure closing the first end of the elongate conduit and the second end of the elongate conduit open and b) from the second location to the first location with the second closing structure closing the second end of the elongate conduit and the first end of the elongate conduit open.

In one form, there is a first cap for selectively closing the first end of the elongate conduit and a second cap for closing the second end of the elongate conduit. There is structure cooperating between the guiding structure and the first and second end caps to guide relative movement between a) a first position wherein the first end cap closes the first end of the elongate conduit and the second end of the elongate conduit is open and b) a second position wherein the second end cap closes the second end of the elongate conduit and the first end of the elongate conduit is open.

In one form, the structure cooperating between the guiding structure and the first and second end caps includes at least one elongate rail and structure cooperating between the elongate rail and at least one of the guiding structure and the first and second end caps for guiding relative movement between the elongate rail and the at least one of the guiding structure and the first and second end caps as the guiding structure and first and second end caps are relatively moved between the first and second positions.

The part receptacle has a storage space and an entry opening communicating with the storage space. In one form, the guiding structure guides movement of the parts receptacle between a loading position and an unloading position and includes structure for controllably repositioning the part receptacle so that the entry opening in the part receptacle is consistently oriented relative to the guiding structure in both the loading and unloading positions.

In one form, the structure for controllably repositioning the part receptacle includes a pin on one of the part receptacle and guiding structure and a groove for accepting the pin on the other of the part receptacle and guiding structure.

The structure for controllably repositioning the part receptacle may reposition the part receptacle by rotating the part receptacle about an axis as the part receptacle is moved between its loading and unloading position.

In one form, the structure for controllably repositioning the part receptacle positions the part receptacle in its unloading position so that the part therein passes through the entry opening under the force of gravity.

The structure for controllably repositioning the part receptacle, in one form, rotates the part receptacle about an axis through approximately 180° as the part receptacle is moved between its loading and unloading positions.

The part receptacle may have a body with a discharge opening communicating through the body to the part storage

space and a closure element mounted to the body for pivoting movement between open and closed positions. Cooperating structure can be provided on the guiding structure and part receptacle for allowing the closure element to move from one of its open and closed positions to the other of its open and closed positions as an incident of the part receptacle moving between the first and second location.

Structure can be provided for treating a part in the part receptacle with the part receptacle in a treating position between the loading and unloading positions. The structure for controllably repositioning the part receptacle relative to the guiding structure preferably consistently orients the part receptacle relative to the guiding structure with the part receptacle in the treating position.

In one form, the treating structure directs a flowable material, such as air or a liquid, against a part in the part receptacle with the part receptacle in the treating position. There may be additional structure for accumulating a flowable material directed against the part in the part receptacle.

Structure may be provided cooperating between the guiding structure and part receptacle for limiting movement between the part receptacle and the guiding structure in at least one relative position, such as the treating position.

Flowable material can be directed through the entry opening, against a part in the storage space and out a discharge opening, where it may be accumulated.

The invention further contemplates the above structure in combination with a machine for performing an operation on a part and structure for transferring a part worked on by the machine to the part receptacle at the first location.

In another form of the invention, an apparatus is provided for conveying discrete parts in a part receptacle between first and second locations. The conveying apparatus has structure for guiding movement of a part receptacle between the first and second locations and structure for conveying a part receptacle a) from the first location to the second location and b) from the second location to the first location.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevation view of an apparatus for conveying discrete parts in a predetermined path, according to the present invention, and operatively associated with schematically shown parts delivering and receiving mechanisms, with a movable part receptacle on the apparatus shown in a loading position;

FIG. **2** is a view as in FIG. **1** showing the part receptacle conveying from right to left toward the loading position of FIG. **1**;

FIG. **3** is a plan view of the inventive apparatus with the part receptacle conveying as in FIG. **2**;

FIG. **4** is a plan view of the inventive apparatus showing the part receptacle conveying from left to right from the loading position toward an unloading position;

FIG. **5** is a side elevation view of the part receptacle;

FIG. **6** is a side elevation view of a modified form of the inventive apparatus including a treating system for directing a flowable material against a part in the part receptacle;

FIG. **7** is a plan view of the inventive apparatus in FIG. **6**;

FIG. **8** is an enlarged cross-sectional view of the inventive apparatus taken along line **8—8** of FIG. **6**;

FIG. **9** is a side elevation view of a further modified form of conveying apparatus, according to the present invention, which guides movement of the part receptacle in a path that

is different than the path for the part receptacle defined by the apparatus in FIGS. **1–8**;

FIG. **10** is a plan view of the conveying apparatus of FIG. **9**;

FIG. **11** is a schematic side elevation view of a modified form of part receptacle for use in the apparatus of FIG. **9** and operatively associated with a conduit for guiding movement thereof; and

FIG. **12** is an enlarged, side elevation view of the part receptacle in FIG. **11**.

DETAILED DESCRIPTION OF THE DRAWINGS

In FIGS. **1–5**, one form of conveying apparatus, according to the present invention, is shown at **10**. The conveying apparatus has a wide range of applications and can be used to convey parts of different size and shape. In FIG. **5**, one exemplary part **12** is shown and is intended only to be illustrative of parts that can be conveyed with the apparatus **10**.

One exemplary system into which the parts conveying apparatus **10** can be incorporated is shown schematically in FIG. **1**. In FIGS. **1–5**, a machine tool **14** is shown and may take any form and may perform one or a number of diverse operations on the part **12**. After completion of the machining operation(s), the part **12** is moved by a transfer mechanism **16** from the working area around the machine tool **14** to a first location **18** at which the part **12** is placed in a receptacle **20**.

The part receptacle **20** has a body **22** defining a temporary parts storage space **24**. A means at **26** guides movement of the part receptacle **20** with the part **12** therein from the first location **18** to a second location **28**. The part **12** is then released to a point of use **30**, which may be a collection bin or a work station for another machine tool (not shown), which performs another operation on the part **12**.

The guiding means **26** includes an elongate conduit **32** defining an internal space **34** within which the part receptacle **20** is guided between the first and second locations. Preferably, the space **34** has a uniform, circular cross section throughout its length. The conduit **32** has first and second open ends **36**, **38**, with there being means, in the form of end caps **40**, **42**, for selectively closing the open ends **36**, **38** of the conduit **32**. Means including diametrically oppositely located guide rails **44**, **46** cooperate between the conduit **32** and the first and second caps **40**, **42** to guide relative movement between a first position, shown in FIG. **4**, wherein the end cap **40** closes the first conduit end **36** and the second conduit end **38** is open, and a second position, shown in FIGS. **1–3**, wherein the second end cap **42** closes the second end **38** of the conduit **32** and the first end **36** of the conduit **32** is open.

With the conveying apparatus **10** in the first state, shown in FIG. **4**, means **48** can be operated to convey the part receptacle **20** from left to fight within the conduit space **34** from the first location, which represents the loading position, to the second location at the opposite end of the conduit **32**, which represents the unloading position.

In one form, the means **48** is a pneumatic means including a conduit **50** carried on the end cap **40** which controllably directs air from a pressurized supply **52** from left to right into the conduit space **34** against the receptacle **20** to thereby convey the receptacle **20** from the first location **18** to the second location **28**. The means **48** for conveying the part receptacle **20** includes a second conduit **54** associated with

the end cap **42** for directing pressurized air from a supply **56** from right to left through the conduit **32** against the receptacle **20** to thereby move the receptacle **20** within the space **34** from the unloading position back to the loading position with the apparatus in the second state, as shown in FIGS. **1–3**.

The apparatus **10** is changed between the state in FIGS. **1–3** and that in FIG. **4** by repositioning the conduit **32** relative to the end caps **40, 42**, which is accomplished by a hydraulic or pneumatic cylinder **58**. The cylinder **58** is controlled by an actuator **60** which selectively controls extension and retraction of an actuating rod **62**.

The cylinder body **64** is connected to mounting ears **66** on the top **68** of the conduit **32**. The distal end **70** of the rod **62** is connected to a yoke **72** which extends through approximately 180° around the top of the conduit **32**. The free yoke ends **74, 76** are fixedly connected, one each, to the guide rails **44, 46**. Extension of the rod **62** causes the conduit **32** to shift from left to right, while retraction of the rod **62** causes the conduit **32** to shift from right to left.

The cap **40** has diametrically oppositely projecting mounting ears **78** which allow it to be fixedly attached to the guide rails **44, 46**. The end cap **42** has similar ears **80** which are likewise fixed to the rails **44, 46** so that the spacing between the end caps **40, 42** is fixed. The stroke of the cylinder **58** is set so that with the rod **62** retracted, a chamfered, annular edge **82** on the end cap **40** nests against a mating seat/edge **84** at the conduit end **36**. Retraction of the rod **62** seats an annular edge **86** on the cap **42** against a seat/edge **88** at the conduit end **38**. The conduit has diametrically opposite ear pairs **90, 92** at one end thereof and diametrically opposite ear pairs **94, 96** at the other end thereof to precisely and smoothly guide movement of the conduit **32** along the rails **44, 46** so that the end caps **40, 42** fully seat to close the conduit ends **36, 38**.

A controller **98** is used to coordinate the transfer of the parts **12** from the machine tool **14** and movement of the parts receptacle **20** from the first location **18** to the second location **28**. More particularly, the controller **98** causes the actuator **60** to extend the rod **62** until the end cap **42** closes the conduit end **38**. The controller **98** operates an actuator **100** for the means **48** to thereby allow delivery of pressurized fluid from the supply **56** into the conduit **54** from right to left in FIG. **1** to act against and convey the part receptacle **20** to the loading position. The transfer mechanism **16** is then operated to deposit a part **12** through the space between the end cap **40** and conduit end **36** into the receptacle space **24** through an entry opening **101** in the part receptacle **20** communicating with the space **24**.

The actuator **60** is then operated to retract the rod **62** which moves the conduit **32** from right to left to cause the end cap **40** to seal the conduit end **36**, whereupon an actuator **102** for the second means **48** is operated to permit pressurized fluid from the supply **52** to be directed through the conduit **50** and into the conduit space **34** from left to right against the part receptacle **20**, which effects conveyance of the part receptacle **20** to its unloading position.

In a preferred form, the means **26** for guiding movement of the part receptacle includes means at **102** for controllably repositioning the part receptacle **20** as it moves between the first and second locations. More particularly, the means **102** includes guide pins **104, 106, 108, 110** which project radially outwardly from the body **22** of the part receptacle **20**. The center axes for the pins **104, 106, 108, 110** reside substantially in the same plane, with the pins **104, 106** being diametrically opposite and at one end of the part receptacle and the pins **108, 110** being diametrically opposite at the other end of the part receptacle. The pins **104, 108** move in a guide groove **112** in the conduit **32**, while the pins **106, 110** move in a similarly configured guide groove **114**. The grooves **112, 114** are defined by undercuts in the wall **116** of the conduit **32**. Because the movement of the receptacle **20** is controlled, the receptacle **20** is consistently oriented in both the loading and unloading positions.

In a preferred form, the grooves **112, 114** extend in a straight path from the one conduit end **36** to a point beyond the midportion of the conduit. Adjacent to the other conduit end **38**, the grooves **114, 116** move in a helical path as a result of which the part receptacle **20** is caused to rotate, preferably through 180°. With this arrangement, the part receptacle **20** is inverted from its orientation in the loading position so that at the second location **28** the part **12** therein can fall out of the opening **102** into a receptacle or be delivered to another point of use **30**.

To guide smooth movement of the part receptacle **20**, a plurality of circumferentially spaced guide pads **118** are provided on the peripheral surface **120** of the receptacle **20**. These pads **118** maintain concentric relationship between the receptacle **20** and conduit space **34** so that the pins **104, 106, 108, 110** do not bind as they move in the guide grooves **112, 114**.

In FIGS. **6–8**, a modified form of parts conveying apparatus, according to the present invention, is shown at **124**. The apparatus **124** is constructed similarly to the apparatus **10**, previously described, but is modified by including means at **126** for treating a part. A modified form of part receptacle **128** is also used for conveying a part **12** between the first location **18** and the second location **28**. Parts that are the same in the apparatus **10, 124** are numbered the same herein.

The apparatus **124** has a conduit **130** that is similar to the conduit **32**, previously described, but which is cut out at its bottom to accommodate a funnel-shaped collector **131**. The collector **131** accumulates a flowable material, which is generally a liquid, from a pressurized supply **132** thereof. The flowable material may be a lubricant, a washing fluid, a flowable solid material, a coating, air or the like.

More particularly, the flowable material from the supply **132** is delivered to an internal parts storage space **134** in the receptacle **128** and against the part therein through feeder tubes **136, 138, 140**. The feeder tube **138** is fixed to the upper wall **142** of the conduit in alignment with an entry opening **144** in the receptacle **128**, with the receptacle **128** in a treating position over the collector **131**.

The feeder tubes **136, 140** include nozzles **146, 148**, which are radially extendable and retractable through an actuator **150**, and feed portions **152, 154** integrally formed with the receptacle **128**. The feed portions **152, 154** are shaped to direct pressurized flowable material against a part **12** in the storage space **134** from opposite ends thereof to effect thorough coverage of the part **12**.

Receptacle stops **156, 158** project radially through the conduit wall **160** at diametrically opposite locations. Through an actuator **162**, the stops **156, 158** are simultaneously selectively extended into the space **163** bounded by the conduit wall **160** and retracted therefrom. With the stops **156, 158** in an extended position, the receptacle **128** abuts thereto in the proper treating position as it moves from the loading position towards the unloading position.

With the receptacle **128** in the treating position, the actuator **150** is operated to extend the nozzles **146, 148** against the feed portions **152, 154** to establish communication between the supply **132** and the part storage space **134**.

An actuator **164** is then operated by the controller **98** to release the flowable material from the supply **132** into the feed tubes **136, 138, 140** to thereby shower the part **12** in the receptacle.

The flowable material in the space **134** escapes through a discharge opening **166** at the bottom of the receptacle **128** and is accumulated in the collector **131.** At the bottom of the collector, a pivotable valve **168** is provided to selectively close and open a necked-down outlet **170** at the bottom of the collector **131.** An actuator **172** selectively moves the valve **168** from the open solid line position in FIG. **6** to the closed phantom line position in response to a signal from the controller **98.**

A supply of air can optionally be directed into the space **134** through the feed tubes **136, 138, 140,** as a substitute for the liquid and/or solid flowable material or after that flowable material from the supply **132** is introduced, as to effect cleaning and/or drying of the part **12.** Once the treating step is concluded, the feed tubes **136, 140** and stops **156, 158** can be retracted to allow continued passage of the receptacle **128** fully through to the unloading position. The receptacle **128** is rotated as it conveys toward the unloading position so that it is inverted and releases the contained pan which falls by gravity through the space between the end cap **42** and conduit end **38.**

In FIGS. **9–12**, a further modified form of apparatus for conveying parts, according to the invention, is shown at **176.** The principal difference between the apparatus **176** and the apparatus **124** is in the construction of the pans receptacle **178,** which allows the receptacle **178** to be loaded and unloaded without rotating the receptacle as it approaches the unloading position.

The receptacle **178** has a parts storage space **180** and an entry opening **182** communicating through a wall **183** on the receptacle with the space **180.** A parts discharge opening **184** is provided in the bottom of the receptacle wall **183.** A closure element **186** is connected to the receptacle wall **183** for pivoting movement relative thereto about a pivot pin **188.** A spring **190** normally biases the closure element **186** to a closed position, as shown in FIG. **9.** The closure element **186** is movable from the closed position to the open position, shown in FIG. **2,** preferably under the weight of the part **12.** The spring **190** develops a sufficient force to maintain the closure element **186** closed in the absence of a part **12** resting thereagainst.

With the closure element **186** closed and a part **12** in the storage space **180,** the closure element **186** is releasably maintained in its closed state by a means/latch assembly at **192.** The latch assembly **192** includes an actuator pin **194** and an L-shaped latch element **196** that is connected to the receptacle wall **182** for pivoting movement relative thereto about a pin **198.**

With the closure element **186** in the closed position of FIG. **9,** the latch element **196** is pivoted in a clockwise direction in FIG. **12** about the pin **198** to situate one leg **200** of the latch element underneath the closure element **186** to thereby prevent the closure element **186** from moving into its open position even with a part in the receptacle. With the latch element **196** in the latched position, the other leg **202** of the latch element **196** drives the actuating pin **194** to the loaded position in FIG. **9.**

As the pan receptacle **178** is conveyed/propelled from left to right in FIGS. **9** and **10,** the facing wall **204** on the end cap **42** depresses the actuating pin **194.** The depressed pin acts on the leg **202** to effect a counterclockwise pivoting of the latch element **196** from the FIG. **9** position. As this occurs, the leg **200** clears away from the pivot path for the closure element **186,** whereupon the weight of the part **12** in the part receptacle **178** urges the closure element **186** from the closed position of FIG. **9** to the open position of FIG. **12.**

As the closure element **186** opens, the part **12** therein drops through the discharge opening **184** and through the space **206** between the conduit **130** and the end cap **42** to be delivered to a point of use **30.**

The latch element **196** can be automatically reset under the force of a spring **208,** which normally biases the latch element **196** into the latched position shown in FIG. **9.** After the part **12** is released from the storage space **180,** the spring **190** will urge the closure element **186** back to its closed position. With the conduit **130** repositioned against the end cap **42,** the receptacle **178** can be propelled from right to left as previously described. As this occurs, the spring **208** urges the latch element **196** back to its latch position and thereby reloads the actuator pin **194.**

While the embodiment in FIGS. **9–12** shows a means for treating parts **126,** this means **126** is optional.

The foregoing disclosure of specific embodiments is intended to be illustrative of the broad concepts comprehended by the invention.

I claim:

1. An apparatus for conveying discrete parts between first and second locations, said conveying apparatus comprising:

a receptacle for at least one part;

an elongate conduit defining an internal space within which the part receptacle is guided between the first and second locations, said elongate conduit having first and second ends, there being a first cap for selectively closing the first end of the elongate conduit and a second cap for selectively closing the second end of the elongate conduit, there further being means cooperating between the elongate conduit and the first and second end caps to guide relative movement of the first and second end caps and elongate conduit between a) a first position wherein the first end cap closes the first end of the elongate conduit and the second end of the elongate conduit is open and b) a second position wherein the second end cap closes the second end of the elongate conduit and the first end of the elongate conduit is open; and

means for exerting a force on the part receptacle and thereby conveying the part receptacle selectively a) from the first location to the second location and b) from the second location to the first location.

2. The parts conveying apparatus according to claim **1** wherein the means for conveying the part receptacle comprises means for controllably delivering a pressurized fluid against the part receptacle to at least one of a) move the part receptacle from the first location to the second location and b) move the part receptacle from the second location to the first location.

3. An apparatus for conveying discrete parts between first and second locations, said conveying apparatus comprising:

a receptacle for at least one part;

an elongate conduit defining an internal space within which the part receptacle is guided between the first and second locations, said elongate conduit having first and second ends, there being a first cap for selectively closing the first end of the elongate conduit and a second cap for selectively closing the second end of the elongate conduit, said first cap closing the first end of the elongate conduit with the elongate conduit and first and second caps in a first relative position, said second

cap closing the second end of the elongate conduit with the elongate conduit and first and second caps in a second relative position, there further being means cooperating between the elongate conduit and the first and second end caps comprising at least one elongate rail and means cooperating between the at least one elongate rail and at least one of the elongate conduit and the first and second end caps for guiding relative movement between the at least one elongate rail and the at least one of the elongate conduit and the first and second end caps as the elongate conduit and first and second end caps are relatively moved between the first and second positions; and

means for exerting a force on the part receptacle and thereby conveying the part receptacle selectively a) from the first location to the second location and b) from the second location to the first location.

4. The parts conveying apparatus according to claim **3** wherein the elongate conduit guides movement of the part receptacle between a loading position and an unloading position, said pans conveying apparatus further including means for treating a pan in the pan receptacle with the part receptacle in a treating position between the loading and unloading positions.

5. The parts conveying apparatus according to claim **4** wherein there are means cooperating between the part receptacle and elongate conduit for controllably repositioning the part receptacle relative to the elongate conduit so that the part receptacle is consistently oriented relative to the part receptacle with the part receptacle in the treating position.

6. The parts conveying apparatus according to claim **4** wherein the treating means comprises means for directing a flowable material against a part in the part receptacle with the part receptacle in the treating position.

7. The parts conveying apparatus according to claim **6** including means for accumulating flowable material directed by the means for directing a flowable material against a part in the part receptacle.

8. The parts conveying apparatus according to claim **4** wherein the part receptacle has a body with a parts storage space, a discharge opening communicating through the body to the parts storage space, a closure element, and means for mounting the closure element to the body for movement between open and closed positions, there being means cooperating between the elongate conduit guiding means and part receptacle for allowing the closure element to move from one of its open and closed positions to the other of its open and closed positions as an incident of the part receptacle moving between the first and second locations.

9. The parts conveying apparatus according to claim **8** wherein the means for mounting the closure element to the body of the part receptacle comprises means for mounting the closure element to the body of the part receptacle for pivoting movement between open and closed positions.

10. The parts conveying apparatus according to claim **4** wherein the part receptacle has a body defining a parts storage space and entry and discharge openings communicating through the body to the pans storage space and the treating means comprises means for directing flowable material through the entry opening against a part in the storage space and through the discharge opening with the part receptacle in the treating position.

11. The parts conveying apparatus according to claim **10** including means for accumulating flowable material directed out the discharge opening in the part receptacle.

12. The parts conveying apparatus according to claim **3** including means cooperating between the elongate conduit and part receptacle for limiting movement between the part receptacle and elongate conduit in at least one relative position.

13. The parts conveying apparatus according to claim **3** wherein the part receptacle has a part storage space and an entry opening communicating with the storage space and the elongate conduit guides movement of the part receptacle between a loading position and an unloading position and includes means for controllably repositioning the part receptacle so that a part in the part receptacle passes through the entry opening in the part receptacle under the force of gravity with the part receptacle in the unloading position.

14. The parts conveying apparatus according to claim **13** wherein the means for controllably repositioning the part receptacle comprises means for rotating the part receptacle about an axis through approximately 180° as the part receptacle is moved between its loading and unloading position.

15. The parts conveying apparatus according to claim **3** in combination with a machine for performing an operation on a part and means for transferring a part worked on by the machine to the part receptacle in the first location.

16. The parts conveying apparatus according to claim **15** wherein the part receptacle has a pans storage space and an entry opening communicating with the parts storage space and the means for conveying the part receptacle includes means for repositioning the part receptacle at the second location so that a part in the part storage space discharges through the entry opening.

17. The parts conveying apparatus according to claim **3** wherein the means for conveying the part receptacle comprises means for controllably delivering a pressurized fluid against the part receptacle to at least one of a) move the part receptacle from the first location to the second location and b) move the part receptacle from the second location to the first location.

18. An apparatus for conveying discrete parts in a part receptacle between first and second locations, said conveying apparatus comprising:

an elongate conduit defining an internal space within which a part receptacle is guided between the first and second locations, said elongate conduit having first and second ends, there being a first cap for selectively closing the first end of the elongate conduit and a second cap for selectively closing the second end of the elongate conduit, there further being means cooperating between the elongate conduit and the first and second end caps to guide relative movement of the elongate conduit and first and second end caps between a) a first position wherein the first end cap closes the first end of the elongate conduit and the second end of the elongate conduit is open and b) a second position wherein the second end cap closes the second end of the elongate conduit and the first end of the elongate conduit is open; and

means for exerting a force on the part receptacle and thereby conveying a part receptacle selectively a) from the first location to the second location and b) from the second location to the first location.

19. The parts conveying apparatus according to claim **18** further including means for treating a part in a part receptacle in a treating position between the first and second locations.

20. The parts conveying apparatus according to claim **18** wherein the means for conveying the part receptacle comprises means for controllably delivering a pressurized fluid against the part receptacle to at least one of a) move the part receptacle from the first location to the second location and

b) move the part receptacle from the second location to the first location.

21. An apparatus for conveying discrete parts in a part receptacle between first and second locations, said conveying apparatus comprising:

an elongate conduit defining an internal space within which a part receptacle is guided between the first and second locations, said elongate conduit having first and second ends, there being a first cap for selectively closing the first end of the elongate conduit and a second cap for selectively closing the second end of the elongate conduit, there further being means cooperating between the elongate conduit and the first and second end caps for guiding movement of the first and second end caps relative to the elongate conduit between a) a first position wherein the first end cap closes the first end of the elongate conduit and b) a second position wherein the second end cap closes the second end of the elongate conduit, said guiding means including at least one elongate rail and means cooperating between the at least one elongate rail and at least

one of the elongate conduit and the first and second end caps for guiding relative movement between the at least one elongate rail and the at least one of the elongate conduit and the first and second end caps as the elongate conduit and first and second end caps are relatively moved between the first and second positions; and

means for exerting a force on the part receptacle and thereby conveying a part receptacle a) from the first location to the second location and b) from the second location to the first location.

22. The parts conveying apparatus according to claim **21** wherein the means for conveying the part receptacle comprises means for controllably delivering a pressurized fluid against the part receptacle to at least one of a) move the part receptacle from the first location to the second location and b) move the part receptacle from the second location to the first location.

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